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UPPER DEVONIAN CONODONTS FROM HAY RIVER - FORT SIMPSON AREA

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled UPPER DEVONIAN CONODONTS FROM HAY RIVER - FORT SIMPSON AREA submitted by JOHAN FREDERIK APON in partial fulfilment of the requirements for the degree of Master of Science.

ABSTRACT

A rich sequence of conodont faunas was obtained from the Fort Simpson, Escarpment, Twin Falls, Tathlina, Redknife, Kakisa, and Trout River formations. Over four thousand specimens were recovered. The conodonts identified are all of Late Devonian age, ranging from the early Frasnian to the late Famennian.

The following zones, established by Ziegler (1962b) for the Upper Devonian, are recognized: the *Mesotaxis asymmetrica* Zone, the *Ancyrognathus triangularis* Zone, and the *Palmatolepis gigas* Zone. Limited stratigraphic ranges of various species of *Polygnathus* in the study area made it possible to erect some local range zones that can be tied in to Ziegler's zonal scheme.

Observations of material from the Hay River - Fort Simpson area led to the recognition of two distinct biofacies: a *Polygnathus/Icriodus* biofacies; and a *Polygnathus/Polygnathus* biofacies. There is some indication that the geographic distributions of conodonts may have been controlled by variation in salinity and/or temperature.

The multielement species *Polygnathus webbi* is identified. It was recognized qualitatively. Some elements of the multielement species *Ancyrodella rotundiloba* also appear to be present.

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INTRODUCTION

HISTORY OF STRATIGRAPHIC NOMENCLATURE

Upper Devonian rocks outcrop south of the upper Mackenzie River and Great Slave Lake. Exposure of these rocks is largely restricted to river valleys, which in this area take the form of deep, steep gorges. Important examples of this type of outcrop are found along Hay River, Trout River, and Kakisa River.

The Mackenzie River and Great Slave Lake have always been part of an important transportation link to the north; therefore, exploration of this area began early in Canadian history. The first person to make any published observations pertaining to the geology of this region was McConnell (1891). Cameron (1917, 1918) explored the area and was the first to assign formational names to the rock units along the Hay River. He called the lower part of the section the Hay River Shales and the upper part, the Hay River Limestones. Whittaker (1922, 1923) extended our knowledge of the distribution of these units by including outcrops along the Bouvier, Redknife, Trout and Kakisa rivers. Crickmay (1953, 1957) later proposed some additional formational names. He called the Hay River Shales the Hay River Formation, and he subdivided the Hay River Limestones into the Alexander and Grumbler formations. Douglas (1959) produced a preliminary map of the area and a report, in which he used informal map units. Belyea and McLaren (1961) proposed a multi-formational scheme, resulting in the following formations (from oldest to youngest): Fort Simpson, Hay River, Twin Falls, Tathlina, Redknife, Kakisa, Trout River, Tetcho and Kotcho. Both the Hay River and the Twin Falls formations were

divided up into members; the Hay River consisting of the Lower and the Escarpment members and the Twin Falls consisting of the Alexander and Upper members. House and Pedder (1963) considered the Hay River Formation to be equivalent to the Fort Simpson Formation, and therefore regarded the former name as a junior synonym.

In this thesis, the scheme proposed by House and Pedder (1963) is used. In Fig. 1 the history of the stratigraphic nomenclature of this area is illustrated.

PURPOSE OF STUDY

The purpose of this study is to elucidate the taxonomy of conodonts, biostratigraphic usefullness of conodonts, and the paleoecology of conodonts.

Conodonts are valuable index fossils throughout the Paleozoic Era and Triassic Period. A splendid conodont zonation has been developed for the Upper Devonian by Ziegler (1962 a, b; 1971). This is regarded by most workers as a more practical alternative to the standard ammonoid sequence (orthofossils). These conodont zones, which were first recognized in Germany, can now be traced throughout much of the world. Some of the objectives of the present investigation are to establish the presence, distributions, and stratigraphic positions of Ziegler's conodont zones in the southern part of the Northwest Territories.

In recent years an increasing emphasis has been placed on paleoecology. Seddon and Sweet (1971) and Barnes, Rexroad and Miller (1973) have proposed two different models to interpret the life mode of the conodontophorids. This study touches on aspects of the paleoecology

		CAMERON 1917-1918	WHITTAKER 1922, 1923	CRICKMAY 1953, 1957	DOUGLAS 1959	BELYEA & McLAREN 1961	HOUSE & PEDDER 1963
UPPER DEVONIAN	FAMENNIAN		DESCRIPTION TAKEN TO TOP OF TROUT RIVER SECTION				
		ONLY INVESTIGATED HAY RIVER	HAY RIVER LIMESTONES	PALLISER FORMATION	22	TETCHO FORMATION	TETCHO FORMATION
				TROUT RIVER FORMATION		TROUT RIVER FORMATION	TROUT RIVER FORMATION
	FRASNIAN			GRUMBLER FORMATION	21	KAKISA FORMATION	KAKISA FORMATION
					20	REDKNIFE FORMATION	REDKNIFE FORMATION
					19	TATHLINA FORMATION	TATHLINA FORMATION
		HAY RIVER LIMESTONES		ALEXANDER FORMATION	18 17	TWIN FALLS FORMATION	TWIN FALLS FORMATION
		HAY RIVER SHALES	HAY RIVER SHALES	HAY RIVER FORMATION	16	HAY RIVER FORMATION	ESCARPMENT FORMATION
					15		FORT SIMPSON FORMATION

Figure 1 - History of stratigraphic nomenclature

of these elusive creatures.

Workers have recently come to realize that the conodont-bearing animal contained a number of different discrete elements. This has placed increasing emphasis on multielement taxonomy, for, prior to this, the individual form elements were described and classified as different species. Today, most workers are attempting to reconstruct apparatuses using quantitative and/or qualitative methods. Klapper and Philip (1971, 1972) and Philip and McDonald (1975), in qualitative works, proposed a number of Devonian conodont apparatuses. Some of these can be recognized in the Upper Devonian strata of the Hay River area.

PROCEDURE

Belyea and McLaren (1961) proposed a formational scheme for this area and identified a number of rock units within each of the formations. Using their units, samples were collected in a number of localities, through parts of their described sections (for locations of sections, see Fig. 2). Sampling was controlled by terrain and types of exposure. More samples were collected from limestones than from shales because conodonts are easier to recover from limestone.

A total of eighty samples (approx. 3.0 Kg. in size) were processed using the standard laboratory techniques, involving acid digest, wet sieving with a 100 mesh sieve, heavy liquid separation and picking of the elements under a microscope.

The conodonts were photographed by means of a scanning electron microscope (see plates 1-8) because of the superior depth of field and resolution provided by this instrument at a high magnification.

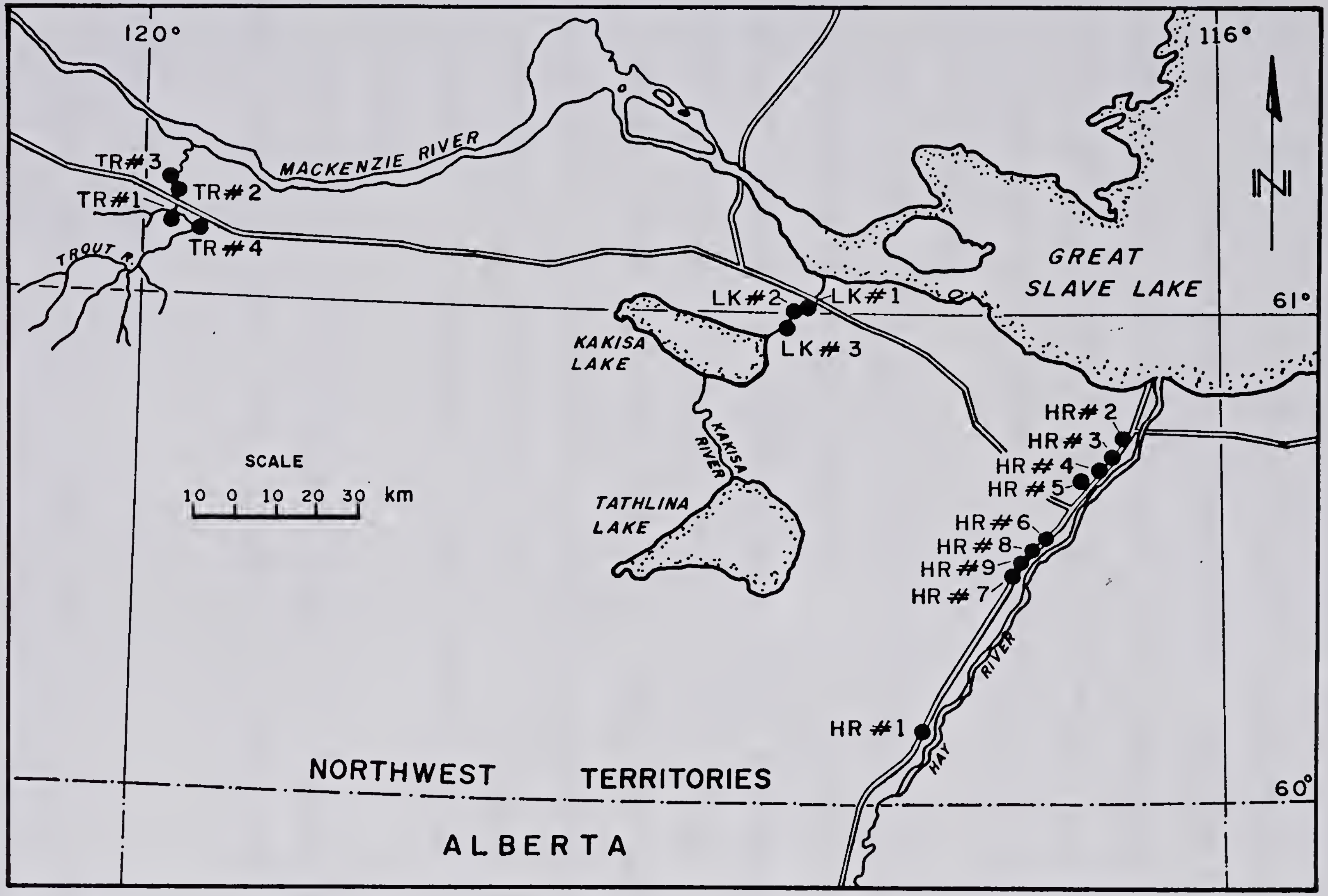


Figure 2 - Locality Map

STRATIGRAPHY

As stated previously, the nomenclature used is that proposed by House and Pedder (1963). The stratigraphic measurements of the sections come from Belyea and McLaren (1961). Conodont samples were collected from the units recognized by Belyea and McLaren. The accuracy of the positions of the samples depended to some extent upon the ability of the writer to recognize Belyea and McLaren's units in the field.

Most of the samples were collected from three sections, each being identified by its own prefix; HR - Hay River section, TR - Trout River section, LK - Kakisa River section. The numbers adjoining the prefix indicate specific localities and horizons along each section, where collection took place. The actual measurement from the base of the formation is recorded in the brackets following the localities (eg. HR #2-50 (30.5:100)). The first number within the brackets is the measurement in meters and the second the measurement in feet.

The relative stratigraphic positions of the formations under investigation are shown in Fig. 1, under the heading House & Pedder.

FORT SIMPSON FORMATION

Cameron (1918) termed the shales that outcrop along the Hay River, the Hay River Shales. Belyea and McLaren (1961) designated the shales exposed on the Hay River as the Lower Member of the Hay River Formation. After reviewing the data and realizing the correlation between the shales on the Hay River and the Fort Simpson Forma-

tion, House and Pedder (1963) converted the name Lower Member of the Hay River Formation to the Fort Simpson Formation.

The Fort Simpson Formation marks the base of the Upper Devonian (Douglas, 1959, Belyea and McLaren, 1961, House and Pedder, 1963). Initially the term Fort Simpson Formation was used to delineate limited shale exposures in the vicinity of Fort Simpson, but subsequently its type section was designated in Briggs Turkey Lake No. 1 Well (Belyea and McLaren, 1961), where it occurs between 238 and 829 meters (780-2,720 ft.). The formation, according to Belyea and McLaren (1961), is 122 meters (400 ft.) thick at the Hay River section, and consists of greenish-grey mudstones and shales. Scattered in these shales are thinly bedded limestones. The formation contains Frasnian brachiopods (Crickmay, 1957).

Belyea and McLaren (1961) considered that the Fort Simpson Formation can be correlated with the Firebag Member of the Waterways Formation, the Beaverhill Formation and the Cooking Lake Formation in Alberta.

Samples were obtained from the thin limestone beds present in the formation. The three samples collected at locality HR #2, where the base of the formation is exposed, HR #2 (0:0); HR #2-50 (15.2:50), and HR #2-100 (30.5:100), contained no conodonts. The next locality, HR #3, produced a rich conodont fauna.

The three rich conodont samples collected from HR #3 were within 3.05 meters of each other, HR #3-base (54.9:180), HR #3-9 (57.6:189) and, HR #3-10 (57.9:190). Together they produced 625 individual conodont elements. The fauna consists of the following species: _Mesotaxis asymmetrica ovalis_ (Ziegler and Klapper), _Polygnathus_ new

species F, Polygnathus new species H, Polygnathus new species I, Polygnathus brevilaminus Branson and Mehl, Polygnathus xylus Stauffer, Ancyrodella rotundiloba (Bryant), Icriodus cf. I. difficilis (Ziegler, Klapper and Johnson), Spathognathodus gradatus (Youngquist). The fauna recovered is characteristic of the Mexotaxis asymmetrica Zone of Ziegler (1962b).

From another locality, HR #4, a total of 67 elements was recovered, the identifiable platform elements being Polygnathus new species F, Polygnathus new species H, Polygnathus new species I, and Polygnathus xylus Stauffer. These samples: HR #4 shale (88.4:290); HR #4 LST (90.2:296) were collected only 1.8 meters apart.

Locality HR #5 produced even fewer specimens, a total of 42, with the identifiable forms being Polygnathus new species F, Polygnathus new species H and Polygnathus xylus Stauffer. These samples came from two limestone horizons (97.6:320 and 120.4:395).

ESCARPMENT FORMATION

This formation was called the Escarpment Member of the Hay River Formation by Belyea and McLaren (1961). House and Pedder (1963) elevated it to formational status. This formation used to be a part of what was termed the Hay River Shale (Cameron 1918).

The formation has its type section along the Hay River, and is composed of 112.80 meters (370 ft.) of olive-grey calcareous mudstones with thin bedded argillaceous limestones (Belyea and McLaren, 1961). A prominent biostromal unit forms the Louise Falls. Within this formation there is a rich fauna of brachiopods and corals. Goniatites

were also reported from this formation by House and Pedder (1963).

The formation is overlain by the Twin Falls Formation, and rests conformably on the Fort Simpson Formation (Belyea and McLaren, 1961).

A total of ten samples were collected from this formation, from two different localities, HR #6 and HR #8. One hundred and ten elements were recovered from these samples after processing. Polygnathus new species F, Polygnathus brevilaminus Branson and Mehl and Spathognathodus cf. S brevis Bischoff and Ziegler, were clearly identifiable. The samples were taken at various intervals from 60 to 110 meters (200 - 360 ft.) above the base of the formation, and were collected from a biostromal limestone.

TWIN FALLS FORMATION

Outcrop of the Twin Falls Formation, at its type section on the Hay River, extends from 1.6 kilometers above Grumbler Rapids to the base of Alexander Falls. The formation was named by Belyea and McLaren (1961) and incorporates Crickmay's (1957) Alexander Formation. The Alexander Formation is now called the Alexander Member, being the lower member of the Twin Falls Formation. Previously, the formation was included in what Whittaker (1922, 1923) termed the Hay River Limestone. This limestone was split into two formations by Crickmay (1957) who called them the Alexander and Grumbler formations. The Upper Member of the Twin Falls Formation incorporates the lower part of the Grumbler Formation. This member consists of 31.1 meters (102 ft.) of predominantly limestones (Belyea and McLaren, 1961). The Upper Member is variably bioclastic and biohermal, with some quartzose sand and silt (Belyea and McLaren, 1961). The two members combined

give a total thickness for the formation at the Hay River section, of 158.80 meters (521 ft.). The formation is overlain by the Tathlina Formation, and lies conformably on the Escarpment Formation.

Of the four samples processed from the Alexander Member, only one sample yielded conodonts. Six specimens were recovered. The sample was quartzose and silty in nature, not being a pure limestone. The localities collected from were HR #8 and HR #9.

Samples collected from these sites are located in the following stratigraphic positions relative to the base of the Twin Falls Formation: HR #8-90 (1.52:5), HR #8-135 (15.2:50), HR #8-145 (18.3:60), HR #9-10 (25.9:85). The only conodonts present were Polygnathus new species F and compound elements.

The yield of conodonts is better from the Upper Member of this formation, especially from one locality, HR #7. Out of eleven samples, over 747 conodonts were found in the lower portion of the Upper Member. The fauna includes Polygnathus webbi Stauffer, Polygnathus brevis Miller and Youngquist, Polygnathus new species D, Polygnathus new species E, Polygnathus new species F, Polygnathus new species G, Icriodus cf. I. difficilis (Ziegler), Spathognathodus gradatus (Youngquist), Ancyrodella lobata Branson and Mehl, and Microcoelodus? new species A. More than 700 conodont elements were recovered from two samples collected at locality HR #1 within about .5 meters of each other. These samples come from the upper meter of the Twin Falls Formation.

The first occurrence here (in the upper meter of the Twin Falls Formation) of Polygnathus unicornis Müller and Müller could indicate that this fauna belongs to the Ancyrognathus triangularis Zone

(Müller and Müller, 1957; Ziegler, 1973).

The Twin Falls Formation is not only exposed along the Hay River but it also outcrops on the Kakisa River about 80 kilometers west of the Hay River. Here the two members of the formation are not recognizable. The formation has undergone lithologic changes and is composed predominantly of shales. The lesser beds of limestone contain an abundance of brachiopods and corals.

Eleven samples were collected from the lower 63 meters of the formation, from localities LK1, LK2, and LK3. A small conodont fauna was recovered containing specimens of *Polygnathus brevis* Miller and Youngquist, *Polygnathus brevilaminus* Branson and Mehl, *Polygnathus* new species G, *Polygnathus* new species H, *Polygnathus* cf. new species D, *Ancyrodella lobata* Branson & Mehl, and *Spathognathodus gradatus* (Youngquist). A total of 394 specimens was recovered.

TATHLINA FORMATION

The Tathlina Formation was defined in Briggs Tathlina Lake Well No. 3 between 103.63 meters (340 ft.) and 237.80 meters (780 ft.), by Belyea and McLaren (1961). The name was proposed by Belyea and McLaren in that same publication.

Only 13 meters (43 ft.) of this formation are exposed along the Hay River, and this is where the conodont samples were collected. On the Hay River section, the Tathlina Formation consists of strongly quartzose, sandy and argillaceous limestones. No corals are present. The contact between the Tathlina Formation and the Twin Falls Formation is remarkably sharp. The top of the Twin Falls is highly coralliferous, whereas the base of the Tathlina has no corals.

Brachiopods were observed in the exposure of the Tathlina Formation. At this locality most of the formation has been eroded away, and is overlain by Cretaceous deposits.

Four samples were processed from this formation: HR #1-5 (1.5:5), HR #1-8 (2.4:8), HR #1-20 (6:20) and HR #1-1 mile upstream (12.20:40); producing in excess of 900 elements. There are specimens of *Polygnathus* new species C, *Polygnathus* new species D, *Polygnathus* new species E, *Polygnathus brevis* Miller and Youngquist, *Polygnathus unicornis* Müller and Müller, *Spathognathodus gradatus* (Youngquist) and *Microcoelodus?* new species A.

REDKNIFE FORMATION

The Redknife Formation, first named by Belyea and McLaren (1961), has its type section along the Trout River. There are two members to this formation, an Upper Member and a lower member, termed the Jean-Marie Member. The total thickness of the Redknife exposed along the Trout River is 70.12 meters (230 ft.) (Belyea and McLaren, 1961).

The Redknife Formation is overlain conformably by the Kakisa Formation and is underlain conformably by the Tathlina Formation.

The Upper Member consists of predominantly calcareous mudstones; the Jean-Marie Member is composed of argillaceous, silty limestones (Belyea and McLaren, 1961). No samples of this formation were collected on the Trout River. The only samples of Redknife that the writer has studied come from cuttings from Briggs Rabbit Lake No. 1 Well. These were obtained from the Geological Survey of Canada.

The only identifiable specimen obtained from the cuttings of this formation was *Polygnathus unicornis* Müller and Müller.

KAKISA FORMATION

The type section of the Kakisa Formation is along the Trout River. The top of the formation is exposed at the top of Coral Falls, and the formation extends to the lowest exposure of massive limestones in the canyon below Whittaker Falls. The formation was named by Belyea and McLaren (1961). It consists of a yellowish-grey to olive-grey, quartzose, silty dolomitic limestone, with argillaceous partings (Belyea and McLaren, 1961). The rocks are strongly bioclastic and contain an abundance of corals and stromatoporoids. The formation on the Trout River has a cumulative thickness of 57.01 meters (187 ft.). The Kakisa Formation, named as the upper Grumbler by Crickmay (1957) and McLaren (1959), contains species of several brachiopod genera, including Devonoproductus, Atrypa, and Theodossia.

The Kakisa Formation lies conformably on the Redknife Formation, and is overlain disconformably by the Trout River Formation.

The bottom 30.5 meters (100 ft.) were collected at approximately 30.5 meter (10 ft.) intervals and ten samples were collected from these massive limestones, producing a fauna consisting of Polygnathus brevis Miller and Youngquist, Polygnathus unicornis Müller and Müller, Polygnathus new species A, Polygnathus new species B, Polygnathus new species C, Palmatolepis subrecta Miller and Youngquist, Ancyrognathus triangularis Youngquist, Spathognathodus gradatus (Youngquist), and Microcoelodus? new species A. A total of 573 conodonts was obtained from these ten samples.

The upper 30 meters of this formation were sampled for conodonts at localities TR #1 and TR #2. Three hundred and twenty-three elements were recovered. The collections from the Kakisa Formation contain

Polygnathus new species C, Polygnathus unicornis Müller and Müller, Polygnathus new species A, Polygnathus new species B, Palmatolepis gigas Miller and Youngquist, and Palmatolepis subrecta Miller and Youngquist. Palmatolepis gigas is characteristic of the Palmatolepis gigas Zone. Its presence in the top of the Kakisa Formation places the formation within the gigas Zone.

TROUT RIVER FORMATION

The Trout River Formation, with its type section on the Trout River, was proposed by Crickmay (1957). His definition included 53 meters (174 ft.) of silty limestone and calcareous siltstones at the top of the Devonian outcrop along the Trout River. Belyea and McLaren (1961) restricted the Trout River Formation to 39.6 meters (130ft.) of quartzose sandy limestones and calcareous sandstones that occur above the Kakisa Formation on the Trout River. The Trout River Formation is overlain by the Tetcho Formation.

McLaren (1959) pointed out the drastic differences between the Trout River Formation and the upper Grumbler Formation (here termed Kakisa Formation). There is a sharp lithologic break from a stromatoporoid coral limestone to a calcareous sandstone. There is also a large faunal break in terms of brachiopods (McLaren, 1959).

These factors strongly indicated that a hiatus exists between the Kakisa and Trout River formations. Although conodonts recovered from the Trout River Formation are few and fragmentary there is some indication of a change in the composition of the conodont fauna.

Samples TR #4-5 (1.52:5), TR #4-10 (3.05:10), TR #4-20 (6.10:20), TR #4-30 (9.1:30), TR #4-40 (12.2:40), TR #4-50 (15.24:50), TR #4-55

(16.77:55) produced a total of 75 conodont elements. The following is a list of the forms recovered: *Palmatolepis subrecta* Miller and Youngquist, *Polygnathus* sp. and *Icriodus?* sp.

The distribution of the faunas within the formations is recorded in Tables I - VI, with the exception of the Redknife and Trout River formations which had too few specimens to record in this fashion.

The notation Pa, Pb, M, Sc, Sb, Sa used in the following tables is a general location notation to express homologous positions of particular form elements in the conodont apparatus.

FORT SIMPSON FORMATION

(section on Hay River)

Locality and sample numbers	HR#2 0	HR#2 50	HR#2 100	HR#3 base	HR#3 9	HR#3 10	HR#4 shale	HR#4 1st.	HR#5 30	HR#5 105
Distance in meters above base of formation	0	15.2	30.5	54.9	57.6	57.9	88.4	90.2	97.6	120.4
Polygnathus xylus					56	23	3		2	
Polygnathus brevilaminus					1?					
Polygnathus n.sp. F				8	25	36	1		2	2
Polygnathus n.sp. H				13	38	6	2		4	
Polygnathus n.sp. I				5	11	1		2		
Mesotaxis asymmetrica ovalis					5	2				
Spathognathodus gradatus				1						
Ancyrodella rotundiloba										
Pa				2	4					
Pb				1	10	3				
Icriodus cf. *I. difficilis*				9	33	8				
Elements of a Type 1 apparatus										
Pb				3	29	11	2		2	
M				2	10	12			3	
Sc				3	26	9	2		4	
Sb					4		1		1	
Sa					1					
Elements belonging to either Type 1, Type 2, or Type 3 apparatuses Pb					2					1
Sc					4	4		2		
Pb					10	2				
Unidentifiable elements and fragments				42	80	70	35	6	13	8

Table I - Distribution of conodonts in the Fort Simpson Formation (Hay River section)

ESCARPMENT FORMATION

(section on Hay River)

Locality and sample numbers		HR#6 1	HR#6 5	HR#6 10	HR#6 20	HR#6 25	HR#6 75	HR#6 80	HR#6 100	HR#8 8	HR#8 35
Distance in meters above base of formation		61	63	64	67	69	84	86	92	99	110
Polygnathus n.sp. F.		3			15			1	1	1?	2
Polygnathus brevilaminus		3									
Spathognathodus c f. *brevis*				1							
Elements of a Type 1 apparatus	Pb	1						1			2
	M	2			1						1
	Sc	7	1	2	7			1?	2	6	2
	Sb		2	3	1						1
	Sa	2									
Elements belonging to either Type 1, Type 2 or Type 3 apparatuses	Sc	1			2						
	Pb				1					1	
Unidentifiable elements and fragments			1		25					7	

Table II - Distribution of conodonts in the Escarpment Formation (Hay River section)

TWIN FALLS FORMATION

(section on Hay River)

Locality and sample numbers	HR#8 90	HR#8 135	HR#8 145	HR#9 10	HR#7 11p	HR#7 [illegible]	HR#7 [illegible]	HR#7 7	HR#7 13	HR#7 (a)	HR#7 15	HR#7 18	HR#7 20	HR#7 26	HR#7 35	HR#1 00	HR#1 1 1/2
Distance in meters above base of formation	1.51	15.2	18.3	25.9	31.1	32.0	32.6	33.2	35.0		35.6	36.6	37.2	39.62	41.77	124	124.5
Polygnathus n. sp. F	2																
Polygnathus n. sp. D								8	38	11	38	69	1?			9	137
Polygnathus n. sp. E									3							4	
Polygnathus n. sp. G									4								
Polygnathus webbi Pa												105		3	56		
Pb												37			11		
M												8		1	7		
Sc												21		2	10		
Sb												6			4		
Sa												2					
Polygnathus brevis															1		5
Polygnathus unicornis																5	4
Spathognathodus gradatus								3	3	6	8	16					
Icriodus cf. *I. difficilis*								7	3	8	1						
Ancyrodella lobata								1	1	2							
Microcelodus ? n. sp. A																9	3
Apatognathus sp.																2	
Elements of Type 1 apparatus Pb							1		14	8	8		3?				
M	2							1	14	5	2		1?				
Sc	1							3	7	10	2		5?				
Sb	1								1	4							
Sa											1						
Elements belonging to either Type 1, Type 2 or Type 3 apparatuses Pb																4	27
M																1	8
Sa																1	
Sc																11	16
Sc																3	4
Unidentifiable and broken elements								25		70			7			4	123

Table III - Distribution of conodonts in the Twin Falls Formation (Hay River section)

TWIN FALLS

(Kakisa River Section)

Locality and sample numbers		LK#1 2	LK#1 8	LK#1 20	LK#1 25	LK#1 30	LK#2 0	LK#2 20	LK#3 20	LK#3 43	LK#3 50	LK#3 18
Distance in meters above base of formation		0.6	2.4	6.1	7.6	9.1	2	8.1	48.5	55.5	64.6	70
Polygnathus brevilaminus				5		1	4	11				
Polygnathus n. sp. G.												1
Polygnathus brevis												1
Polygnathus n. sp. H						1		2	1			
Polygnathus sp.							1					
Polygnathus cf.n.sp. D			1	1		2	2					
Spathognathodus gradatus			1				3		3			3
Ancyrodella lobata							1	2				
Apatognathus sp.							2					
Elements associated in a Type 1 apparatus:	Pb			6		4	7	23	2		1	
	M			1	1	1	6	12	1		1	
	Sc	1	6	11	1	10	17	16	1	1	1	
	Sb		4	2			4	10				
	Sa			1			1					
Elements belonging to either Type 1, Type 2, or Type 3 apparatuses	Sa							2				
	M							3				
	Sc				1	4						
Unidentifiable elements and fragments		1	8		7	20	24	80	5	3	4	30

Table IV - Distribution of conodonts in the Twin Falls Formation (Kakisa River section)

TATHLINA FORMATION

(Hay River Section)

Locality and sample numbers		HR#1 5	HR#8 8	HR#1 20	HR#1 1 mile
Distance in meters above base of formation		1.5	2.5	6	12.2
Polygnathus n. sp. D		26	15	31	57
Polygnathus n. sp. C					10
Polygnathus unicornis		5	4	1	1
Polygnathus brevis		9	2	4	
Spathognathodus gradatus			5	5	25
Microcoelodus ? n. sp. A			7	4	12
Apatognathus sp.					3
Elements of Type 1 apparatus	Pb	7	5	6	39
	M	2	5	7	26
	Sc	6	10	39	70
	Sb		3	12	19
	Sa	1	3		9
Elements belonging to eigther Type 1, Type 2, or Type 3 apparatuses	Sc	28		10	
	Pb	6		3	
	Sa	4	4		4
	M	8			11
	Sa				3
Unidentifiable elements and fragments		100	51	20	200

Table V - Distribution of conodonts in the Tathlina Formation (Hay River section)

KAKISA FORMATION

(section on Trout River)

Locality and sample numbers		TR#3 0	TR#3 10	TR#3 20	TR#3 30	TR#3 40	TR#3 50	TR#3 60	TR#3 70	TR#3 80	TR#3 90	TR#2 0	TR#2 20	TR#2 30	TR#2 40	TR#2 50	TR#2 68	TR#1 0	TR#1 5	TR#1 10	TR#1 40	TR#1 top
Distance in meters above base of information		0	3	6.1	9.1	12.2	15.2	18.3	24.4	27.4	30.4	19	25	27	30	33	39	40.9	42.4	43.9	53	56.7
Polygnathus n. sp. C		3	1	3		8		19	35	12	3	50	2	1J		21		9	2		3	1
Polygnathus unicornis				2?	1	9		7	9				2	1.J				1		1		
Polygnathus brevis		1																1				
Polygnathus n. sp. A		4	1	1			1	4	5		1		6			4						
Polygnathus n. sp. B													3			4					1	
Palmatolepis subrecta										2									4			
Palmatolepis gigas																			1			
Spathognathodus gradatus									4	1	3					4						
Microcoelodus ? n. sp. A				2					5	1	2											
Ancyrognathus triangularis													1									
Elements associated with Type 1 apparatus:	Pb		4	5	1	5	4	5	9	8	7	4	3	5		11			1	3	3	1
	M	3	2	2		1	1	4	8	11	4	2	2			9		1	2		1	1
	Sc	5	3	4		8	4	4	7	14	19	4				6		1	1		2	6
	Sb			2					4	3			2									
	Sa			1		2			1	6			1									
Elements belonging to either Type 1, Type 2, or Type 3 apparatuses	M			5				1								3						
	Sc			2	1	5	1	1	?	7	2		1			4						
	Sa			1		2			3		4		1			5						
	Sa			1					2	3	2											
	Pb																					1
Unidentifiable elements and fragments		6	6	30	1	35	40	50	11		34		45	4	5	30	1	13			15	

Table VI - Distribution of conodonts in the Kakisa Formation (Trout River section)

AGE AND CORRELATION

Fossil faunas from the Mackenzie River area were first described by Meek (1868) who accumulated fossils from early explorers in the area. Whiteaves (1891) described more taxa from Meek's collection and realized that these fossils were Late Devonian in age. Both Meek and Whiteaves described a number of corals from the Mackenzie River region. Warren (1944) reported occurrences of Devonian brachiopods from the Hay River limestones and shales.

Warren and Stelck (1950) erroneously placed the base of the Hay River Formation in the *Leiorhynchus castanea* Zone. The problem with this correlation was that the above writers equated *L. castanea* Meek with *L. Hippocastanea* (Crickmay). *Leiorhynchus castanea* is an early Givetian brachiopod, not one of the late Givetian. After *L. Hippocastanea* was recognized as a distinct species, Pedder (1974) produced a revised megafossil zonation for the Middle Devonian and the lower Upper Devonian. His *hippocastanea* Zone contains conodonts belonging to that part of the *hermanni-cristatus* Zone that is latest Middle Devonian. *Leiorhynchus hippocastanea* has not been reported from the Fort Simpson Formation.

House and Pedder (1963) managed to collect some goniatites from the Redknife and Escarpment formations. Both of these formations contained specimens belonging to the genus *Manticoceras*, which is known to occur only in the Frasnian (a Frasnian orthofossil-*Manticoceras* Stufe).

McLaren (1962) reported occurrences of the brachiopods,

Ladogioides pax McLaren from the Hay River Shales (Fort Simpson Formation), and *Calvinaria albertensis opima* McLaren and *Calvinaria albertensis* (Warren) from the Escarpment Formation. These are all Frasnian brachiopods.

Brachiopods from the Trout River Formation suggest that it is probably Famennian in age (McLaren,1959). The boundary between this formation and the Kakisa Formation is thought by many to be a hiatus (McLaren, 1959, and Douglas, 1959). The conodonts obtained from these formations have made it possible to determine the relative ages of these formations.

CONODONT ZONATION

Ziegler (1962a, 1962b, 1971) established an Upper Devonian conodont zonation from sections in the Rhenish Schiefergebirge, Germany. These zones have now been recognized in many parts of the world by numerous workers. Klapper et. al. (1971) discussed North American Devonian conodont biostratigraphy and attempted to recognize Ziegler's scheme for the Upper Devonian.

Pander, the first man to discover conodonts, thought they were fish teeth and thus were nektonic. Since then, many workers have shown a preference for the theory that conodonts were planktonic because individual species have wide lateral distributions (a supposed facies independence). Recently, Seddon (1970), Seddon and Sweet (1971), and Barnes, Rexroad and Miller (1973), have indicated that conodonts are facies dependent, meaning they are controlled by such parameters as temperature and salinity. This makes the application of a single, simple, zonal scheme impossible, and raises the problem

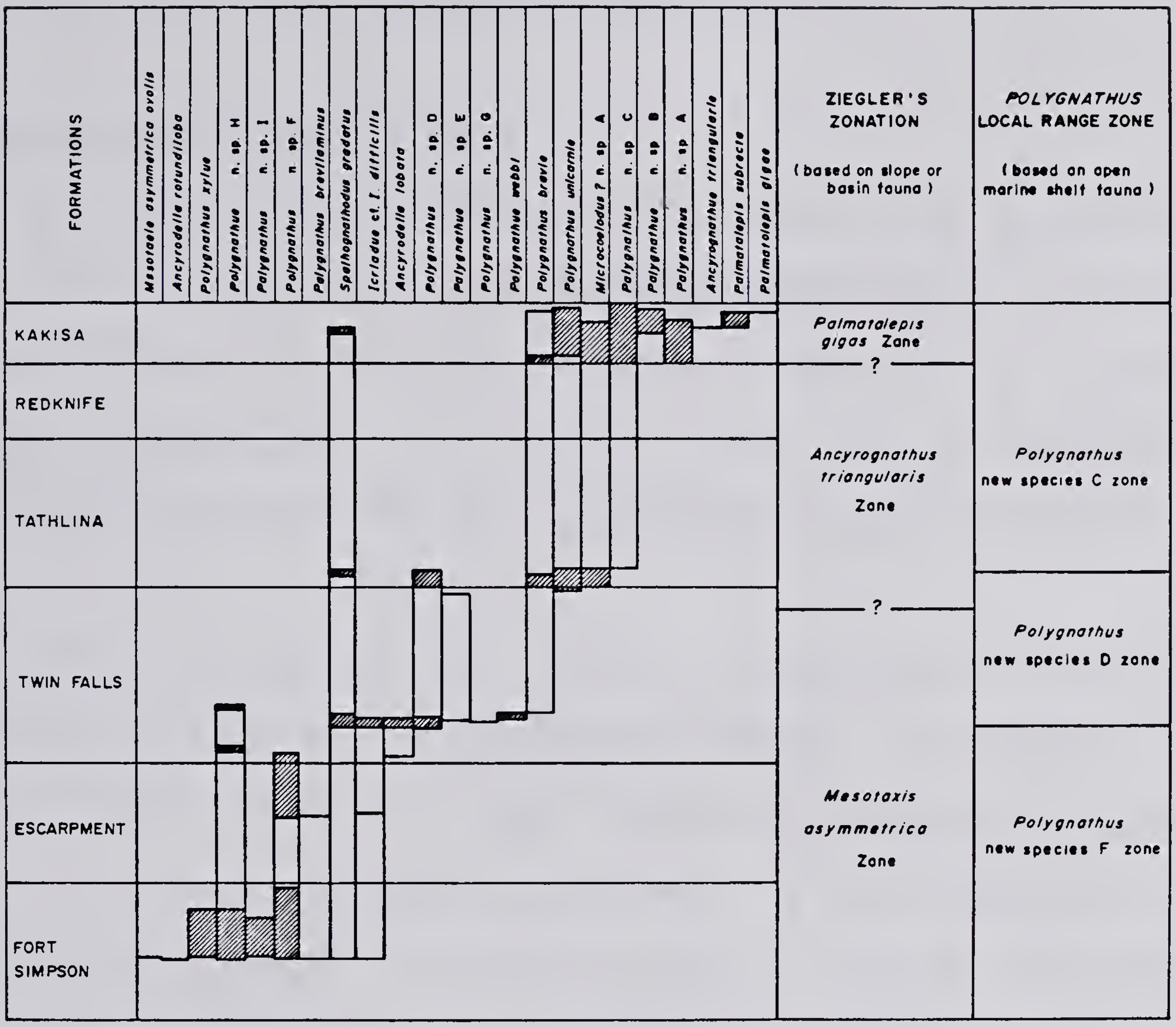
of correlating between different zonal schemes erected for different faunal provinces of facies within a single region.

The most abundant forms recovered from sections on the Hay River, Kakisa River, and Trout River, are elements assigned to the genus Polygnathus. Ziegler (1962b) based his zonation primarily on the form genus Palmatolepis not on Polygnathus. Only two samples, TR #2-20 and TR #1-5 contain any of the name bearers of Ziegler's zones. Within the designated sections of this study, certain species of the form genus Polygnathus have restricted stratigraphic ranges and are useful in correlating strata. Significant stratigraphic occurrences of various conodont species and their correlation with conodont zones are shown in Figure 3.

Mesotaxis asymmetrica Zone

Mesotaxis asymmetrica ovalis and Ancyrodella rotundiloba were recovered from 54.9 meters (180 ft.) above the base of the Fort Simpson Formation. No conodonts were obtained from lower horizons in this formation. According to Klapper, et. al. (1971, p.300), this assemblage is characteristic of the lower asymmetrica Zone. The Spathognathodus insitus fauna described by Uyeno (1967, 1974), which is characteristic of the lowermost asymmetrica Zone in some cases, was not found in this formation.

The first (lowest) occurrence of Ancyrodella lobata is within the lower portion of the Upper Member of the Twin Falls Formation. This form species ranges from the middle asymmetrica Zone up into the gigas Zone (Ziegler, 1971). Because this is the lowest occurrence of this species in the study area and it occurs some distance stratigraphically



Explanation: This chart shows the ranges of various conodont species in the study area. The parts of the graph that are shaded indicate actual occurrence, and outlined parts indicate extrapolated ranges based on scattered occurrences in the sections.

Figure 3 - Conodont zonation

below such taxa as Polygnathus unicornis and Ancyrognathus triangularis, it is quite likely that this part of the Twin Falls Formation belongs to the middle or upper Mesotaxis asymmetrica Zone.

Ancyrognathus triangularis Zone

It was not possible to delineate this zone clearly in the study area. Only one specimen of Ancyrognathus triangularis was recovered. It was obtained from the Kakisa Formation, sample TR #2-20. Ancyrognathus triangularis sf. is reported to range from the Ancyrognathus triangularis Zone into the lower Palmatolepis gigas Zone (Ziegler, 1971).

Another form species with a restricted stratigraphic range that occurs in the study area is Polygnathus unicornis. According to Ziegler (1973) this species ranges from the Ancyrognathus triangularis Zone to the upper Palmatolepis gigas Zone. The first appearance of Polygnathus unicornis in the uppermost part of the Twin Falls Formation is assumed to be near the lower boundary of the Ancyrognathus triangularis Zone. This assumption is based on a distribution of conodonts observed by Müller and Müller (1957).

Palmatolepis gigas Zone

The only occurrence of Palmatolepis gigas in these sections is in the uppermost part of the Kakisa Formation. It occurs with Polygnathus new species C, Polygnathus new species A and Palmatolepis subrecta. Polygnathus new species C ranges from near the base of the Tathlina Formation to the top of the Kakisa Formation. Polygnathus new species A only occurs in the Kakisa Formation. The lower boundary

of the zone is difficult to determine. Ancyrognathus triangularis occurs in the lower part of the formation. It is known to range into the lower Palmatolepis gigas Zone, therefore the lower boundary of this zone is placed at a position equivalent to the base of the Kakisa Formation. More work is necessary to determine the precise range of the Palmatolepis gigas Zone in the area.

Conclusions

As can be understood from the previous discussion concerning the difficulty in the recognition of the zones established by Ziegler, there is a need to establish a zonal scheme based on species of Polygnathus which will be more useful for those working within the shallow continental shelf type facies, where specimens of Polygnathus are frequent and specimens of Palmatolepis are rare.

LOCAL RANGE ZONES

The facies dependent nature of conodonts has made it necessary to examine the feasibility of erecting some local biostratigraphic units. Observations on the distribution of taxa and the relationships between specific taxa in the thesis area make it possible to erect a number of local range zones.

Local range zones are used to indicate the ranges of taxa in a specific area. Boundaries of local range zones are marked by the upper and lower limits of occurrence of specimens of a taxon. It is assumed that the limits are those of the origin and extinction of a particular taxon; however, the boundaries of the zones are based only on the first and last occurrence of specimens in horizons of

a particular section.

Three local range zones are erected based on three new species of *Polygnathus*: *Polygnathus* new species F, *Polygnathus* new species D, and *Polygnathus* new species C. The zones are marked by both the upper and lower limits of the occurrence of these taxa.

Polygnathus new species F range zone

The local range zone of *Polygnathus* new species F is marked by its stratigraphic range. The stratigraphically lowest occurrence of *Polygnathus* new species F in the study area is 54.9 meters (180 ft.) above the base of the Fort Simpson Formation. This horizon is also the lowest in the formation to have yielded conodonts. The occurrence of *Polygnathus* new species F in the Alexander Member of the Twin Falls Formation, 1.51 meters (5 ft.) above the base, is its highest occurrence.

Other forms found with *Polygnathus* new species F in the Fort Simpson Formation are: *Polygnathus xylus*, *Polygnathus brevilaminus*, *Polygnathus* new species H, *Polygnathus* new species I, *Mesotaxis asymmetrica ovalis*, *Spathognathodus gradatus*, *Ancyrodella rotundiloba* (MS) and *Icriodus* cf. *I. difficilis*. In the Escarpment Formation *Polygnathus* new species F occurs with *Polygnathus brevilaminus* and *Spathognathodus* cf. *S brevis*.

Polygnathus new species D range zone

Polygnathus new species D ranges from the base of the Upper Member of the Twin Falls Formation to the lower Tathlina Formation. The boundary between this zone and the *Polygnathus* new species F

range zone remains a question in that conodonts were not recovered from the majority of samples from the Alexander Member. The boundary for the zone has been placed at the boundary between members of the formations. It is interesting to note that the occurrences of *Polygnathus* new species F and *Polygnathus* new species D do not overlap, although some specimens of *Polygnathus* new species F in samples higher in the section began to show more morphological affinities to *Polygnathus* new species D than samples lower down.

In the Upper Member of the Twin Falls Formation, *Polygnathus* new species D occurs with *Polygnathus* new species E, *Polygnathus* new species G, *Polygnathus webbi* (MS), *Polygnathus brevis*, *Polygnathus unicornis*, *Spathognathodus gradatus*, *Icriodus* cf. *I. difficilis* and *Ancyrodella lobata*. In the Tathlina Formation it occurs with *Polygnathus unicornis*, *Polygnathus brevis*, and *Spathognathodus gradatus*. In samples 12.2 meters (40 ft.) above the base of the Tathlina Formation, *Polygnathus* new species C was identified. This form is the characteristic species of the next local range zone.

Polygnathus new species C range zone

The *Polygnathus* new species C zone has its lower limit in the Tathlina Formation and its upper limit at the top of the Kakisa Formation. The exact stratigraphic position and age of the upper limit of the zone are not certain because no conodonts were obtained from the upper part of the Tathlina Formation, and very few forms are known from the Redknife Formation. This boundary could be delineated better by further sampling.

In the one sample from the Tathlina Formation that contained

conodonts, Polygnathus new species C occurs with Polygnathus unicornis and Spathognathodus gradatus. In the Kakisa Formation Polygnathus new species C is associated with Polygnathus new species A, Polygnathus new species B, Polygnathus brevis, Polygnathus unicornis, Ancyrognathus triangularis, Palmatolepis subrecta, Palmatolepis gigas, Spathognathodus gradatus, and Microcoelodus? new species A.

Conclusion

This zonal scheme is based on new taxa which lived on a warm shallow continental shelf. Since these taxa are new, despite the description of numerous species from Frasnian sequences in other parts of the world, it suggests that the zonal scheme may be applicable only over a limited geographical area. Fauna restricted to warm shallow tropical seas commonly have more limited geographic ranges than taxa found in cooler seas. In contrast, the deep water conodont fauna of the same age, dominated by species of Palmatolepis, has already been demonstrated to be widespread geographically.

The zonal scheme discussed may prove to be valuable for correlating shallow open marine environments in the region that is now occupied by western North America.

CORRELATION OF UPPER DEVONIAN STRATA IN WESTERN CANADA

Clark and Ethington (1965) published a paper on conodont biostratigraphy of the Alberta Rocky Mountains. They stated that the uppermost Flume Formation contained a well-preserved Mesotaxis asymmetrica fauna. This was also found in the lower part of the Perdrix Formation. However, they placed the lower part of the Mount

Hawk Formation in the Palmatolepis triangularis Zone, and the upper part of the Mount Hawk Formation in the Palmatolepis rhomboidea Zone.

None of their specimens are truly characteristic of the Palmatolepis triangularis Zone. After consultation with B.D.E. Chatterton and personal observation of the Mount Hawk material which he made available to me, the conodonts were found to belong to the Palmatolepis gigas Zone. Even Palmatolepis gigas is present in the samples observed.

Pollock (1968) accepted the work of Clark and Ethington, basing his correlation partly on their work. He recognized the Mesotaxis asymmetrica Zone in the Beaverhill Lake Formation. He identified the middle asymmetrica Zone at the top of the Maligne Formation. The Ancyrognathus triangularis Zone was not recognized by Pollock in any of his sections. The Palmatolepis gigas Zone was recognized near the base of the Ireton Formation.

Mound (1968) did some conodont work on the Woodbend, Winterburne, and Wabumun Groups. Mound, like Pollock, reported a well-preserved Mesotaxis asymmetrica fauna in the Beaverhill Lake Formation. In the Duvernay Formation, Mound found species belonging to the Ancyrognathus triangularis Zone. Within the Ireton Formation, he reported the occurrence of Palmatolepis gigas and Polygnathus unicornis.

The age of the Waterways Formation was determined by Uyeno (1967, 1974). This formation can be correlated in part with the Upper Devonian section of the study area. Incorporating the observations made by the authors discussed in this section, and the observations made within the study area, a suggested revised correlation chart can be erected for part of the Devonian in Western Canada (See Fig.4).

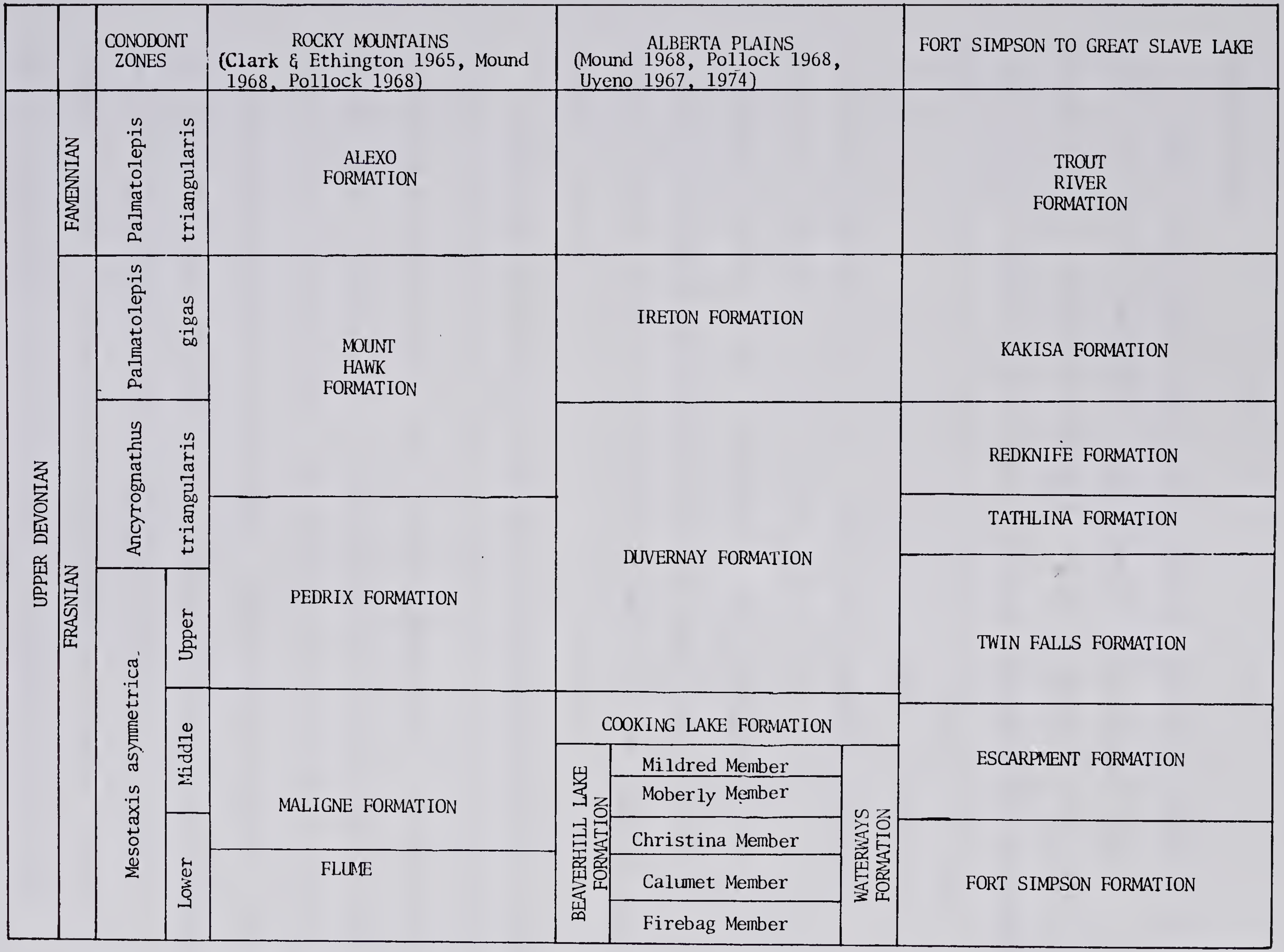


Figure 4 - Suggested correlation chart for Upper Devonian formations in Western Canada

PALEOECOLOGY

INTRODUCTION

Pander, who first discovered conodonts, considered them to be fish, and possibly nektonic. Since Pander, many workers have thought that conodonts were pelagic. This assumption was primarily based on their wide lateral distribution and supposed facies independence. In recent years, however, intensive studies by individual conodont workers (among these, Seddon 1970, Seddon and Sweet 1971, Barnes, Rexroad and Miller 1973, Druce 1973; numerous workers in Barnes, ed., 1976) have shown that conodonts are to some extent facies dependent; and thus their distributions were controlled by some or all of the environmental parameters that controlled the distribution of facies. This discovery led conodont workers into the realm of paleoecology.

Seddon and Sweet (1971) presented an ecological model for conodont animals; and suggested that they may have lived a pelagic but depth-stratified existence similar to that of chaetognaths in Recent oceans. Seddon (1970), working with Frasnian conodonts from the Sadler Ridge, Bugle Gap area, Canning Basin, had previously recognized the existence of two parallel conodont associations. Glenister and Klapper (1966) described conodonts from the Canning Basin, and most forms belong to the genera Palmatolepis and Ancyrodella. Material from Seddon's sections, which is the same age as Glenister and Klapper's material and from the margin of the same basin, is dominated by the genus Icriodus.

Seddon and Sweet's (1971) observations showed that Icriodus

occurred near to shore, close to the fore-reef area of the shelf; and that Palmatolepis dominated the deeper slope and basin facies. They recognized two biofacies, one dominated by Palmatolepis, and another dominated by Icriodus. The recognition of these two biofacies, together with data from the Ordovician of North America, caused them to propose that the conodont animals were pelagic and that different taxa lived at different depths, in a similar manner to Recent chaetognaths (See Fig. 5). Since then, other workers have noticed that genera regarded by Seddon and Sweet as being characteristic of the shallower biofacies are rarer in deeper biofacies than one would expect from the model of Seddon and Sweet (1971).

Druce (1973), working on a paleoecological summary for the Paleozoic, split conodont genera into groups: those which have a wide geographic distribution, those with a patchy distribution, and those that are geographically restricted. For the Devonian, he found that the genera Polygnathus, Palmatolepis and Ancyrodella had a wide geographic distribution. He concluded, from observations of different biofacies throughout the Paleozoic, that genera in Biofacies III (deeper water biofacies) are more diverse than those in Biofacies II (shallower water biofacies); and the genera further from shore are more wide-ranging geographically than genera found near shore. He also suggested that this is related to the preferred life mode of certain genera with respect to the shoreline; and proposed an alternative to, and a variation of, the model of Seddon and Sweet (1971), after noting that the forms which are abundant in the near shore facies are much less abundant away from shore. Fig. 5 shows Seddon and Sweet's (1971) model and the possible alternatives proposed by Druce (1973).

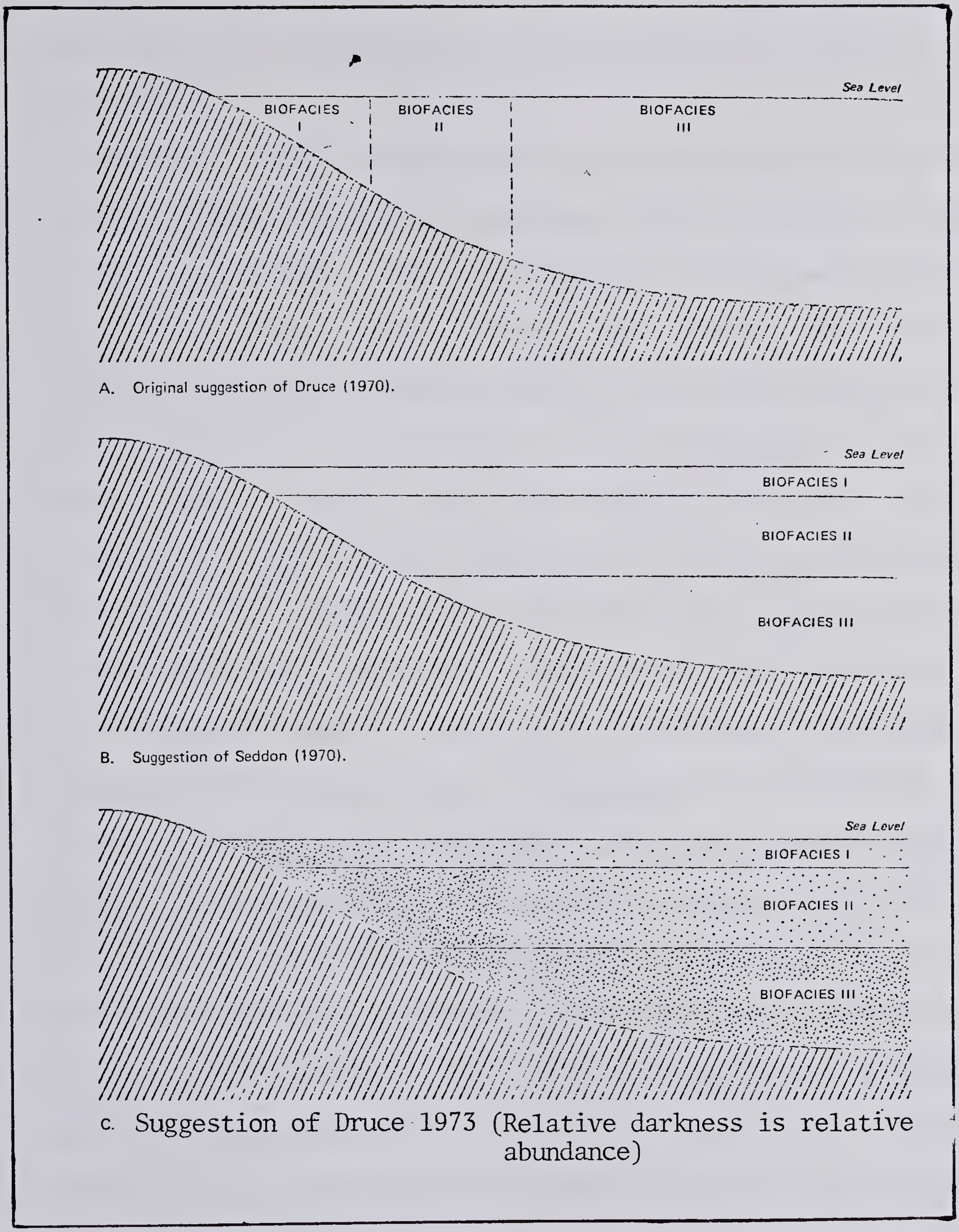


Fig. 5 Conodont Biofacies and Distributions
(After Druce 1973)

Barnes, Rexroad and Miller (1973), from observations made on the distributions of Ordovician conodonts, suggested that some conodonts were nektobenthonic organisms. They stated, in contrast to Seddon and Sweet (1971), that organisms from different depth zones do not often occur together.

Chatterton (1976), working on Middle Devonian material from the southern Northwest Territories, recognized similar biofacies to those set out by Druce (1973). Biofacies II and III of Chatterton (1976) were nearly the same as those of Druce (1973). Druce (1973) and Chatterton (1976) both recognized that, for the Middle Devonian, slope or basin deposits were dominated by the genus Polygnathus. In the Frasnian, which is the same age as the material in the thesis area, the basinal or slope facies is dominated by Palmatolepis (Seddon and Sweet, 1971, Druce, 1973). In the Middle Devonian material in the Northwest Territories, Chatterton (1976) recognized two other biofacies, Biofacies I and IA. Biofacies I is dominated by the genera Panderodus and/or Coelocerodontus (=Walliserodus); and Biofacies IA is dominated by Polygnathus, Belodella, and Coelocerodontus (=Walliserodus). He suggested that the deposits that contain Biofacies I and IA were laid down in semirestricted to restricted environments with higher temperatures and/or salinities than those of open marine regions of the same paleolatitude. He concluded that Panderodus and Coelocerodontus (=Walliserodus) probably were able to tolerate above normal salinities and/or temperatures. He also concluded that the ubiquitous genera were possibly pelagic and that the nonubiquitous genera were possibly benthonic or nektobenthonic. This implied that Icriodus may have been benthonic or nektobenthonic.

Schumacher (1976), who studied conodonts ranging from upper Givetian to lower Frasnian strata, observed that the deeper subtidal facies in the Cedar Valley Formation in Iowa are dominated by Mesotaxis asymmetrica, and Ancyrodella spp. The intermediate subtidal facies are dominated by species of Polygnathus and the shallow subtidal facies are dominated by species of Icriodus. He also observed that there was an increase in diversity of forms seaward, and suggested that there is a dual segregation of genera, those controlled by depth, and those controlled by proximity to shoreline.

Sandberg (1976), working with Famennian conodonts, recognized five biofacies. Two of these biofacies were dominated by Palmatolepis, another two by Polygnathus, and one by Clydognathus (see Fig. 6). He commented that there were more niches and more restricted conodont assemblages nearer to shore. This means that genera with restricted distributions would be found near to shore.

The observation made by most workers, including Druce (1973), Sandberg (1976), Chatterton (1976), and Schumacher (1976), is that no forms are found in all marine facies, and that different conodont taxa have different temporal and geographical distributions. This, together with the markedly different distribution patterns and apparatus patterns and morphologies, would suggest that the conodont animal occupied a number of different niches, and the life modes of various taxa may have been as different as benthonic and pelagic. An attempt is made in Fig. 6 to summarize the interpretations from data on distributions of conodont genera with respect to depth of water made by myself and previous workers for strata of Middle and Late Devonian age.

← INCREASING DEPTH OF WATER

		BIOFACIES III	BIOFACIES II	BIOFACIES I
Sandberg (1976)	Famennian	*Palmatolepis* *Bispathodus* — rise, slope *Palmatolepis* *Polygnathus* — shelf	*Polygnathus* *Icriodus* — outer craton platform *Polygnathus* *Pelekysgnathus* — inner craton platform	*Clydognathus* lagoonal offshore
Druce (1973)	Famennian	*Palmatolepis*, *Polygnathus* *Polyophodonta*	*Icriodus*, *Pelekysgnathus* *Spathognathodus*	Simple cones (*Acodina?*)
Seddon and Sweet (1971)	Frasnian	*Palmatolepis*, *Ancyrodella* (with *Icriodus* off reef)	*Icriodus* with *Polygnathus* near reef	
Druce (1973)	Frasnian	*Palmatolepis*, *Ancyrodella* *Ancyrognathus*	*Icriodus*, *Pelekysgnathus* *Polygnathus*	Simple cone (*Belodella*)
Apon	Frasnian	*Palmatolepis*, *Polygnathus* basin	*Polygnathus* open marine shelf *Polygnathus* *Icriodus*	removed by erosion adjacent to study area
Schumacher (1976)	Upper to Middle Devonian	*Mesotaxis asymmetrica* *Ancyrodella* deep subtidal	*Polygnathus* deep to shallow subtidal *Icriodus* shallow subtidal	
Druce (1973)	Middle Devonian	*Polygnathus*,	*Icriodus*, *Spathognathodus*, *Polygnathus*	*Belodella*
Chatterton (1976)	Middle Devonian	*Polygnathus* slope	*Polygnathus*, *Icriodus* *Pelekysgnathus*, *Belodella* open marine	IA: *Polygnathus* *Belodella* *Coelocerodontus* I: *Panderodus* *Coelocerodontus*

Figure 6 - Summary of distributions of conodont genera relative to depth of water

PALEOGEOGRAPHY

According to Bassett and Stout (1968), the Fort Simpson Formation, and its equivalent the Waterways, can be considered as open marine shales and limestones of a transgressive sea which invaded the Interior Shelf in earliest Late Devonian time. The log correlations, Bassett and Stout (1968), of this interval show that these deposits become thinner by onlap onto topographic highs. During Frasnian time, barrier reef complexes developed farther onto the shelf than during Givetian time.

In Western Canada, the early Frasnian is recognized as a transgressive phase and the later Frasnian is recognized as being a regressive phase. Terrigenous clastics usually marked the end of the Frasnian regression. Some of these formations are the Calmar and Graminia, Sassenach and Trout River formations in the plains and mountains of Alberta and the southern Northwest Territories. If regression occurred in the late Frasnian, one would expect a basinward movement of the carbonate deposits. This can be seen in the Northwest Territories with the Kakisa Formation extending further to the west than the Twin Falls Formation (see Fig. 8).

The Upper Devonian in the Northwest Territories consists predominantly of open marine limestones and shales. Some deposits such as the Kakisa Formation may be biostromal, containing abundant stromatoporoids (Belyea and McLaren 1961 and personal observation). There are indications that the Alexander Member of the Twin Falls Formation may have been semi-restricted due to the presence of *Amphipora* (Bassett and Stout 1968). There is also a rarity of conodonts in this formation.

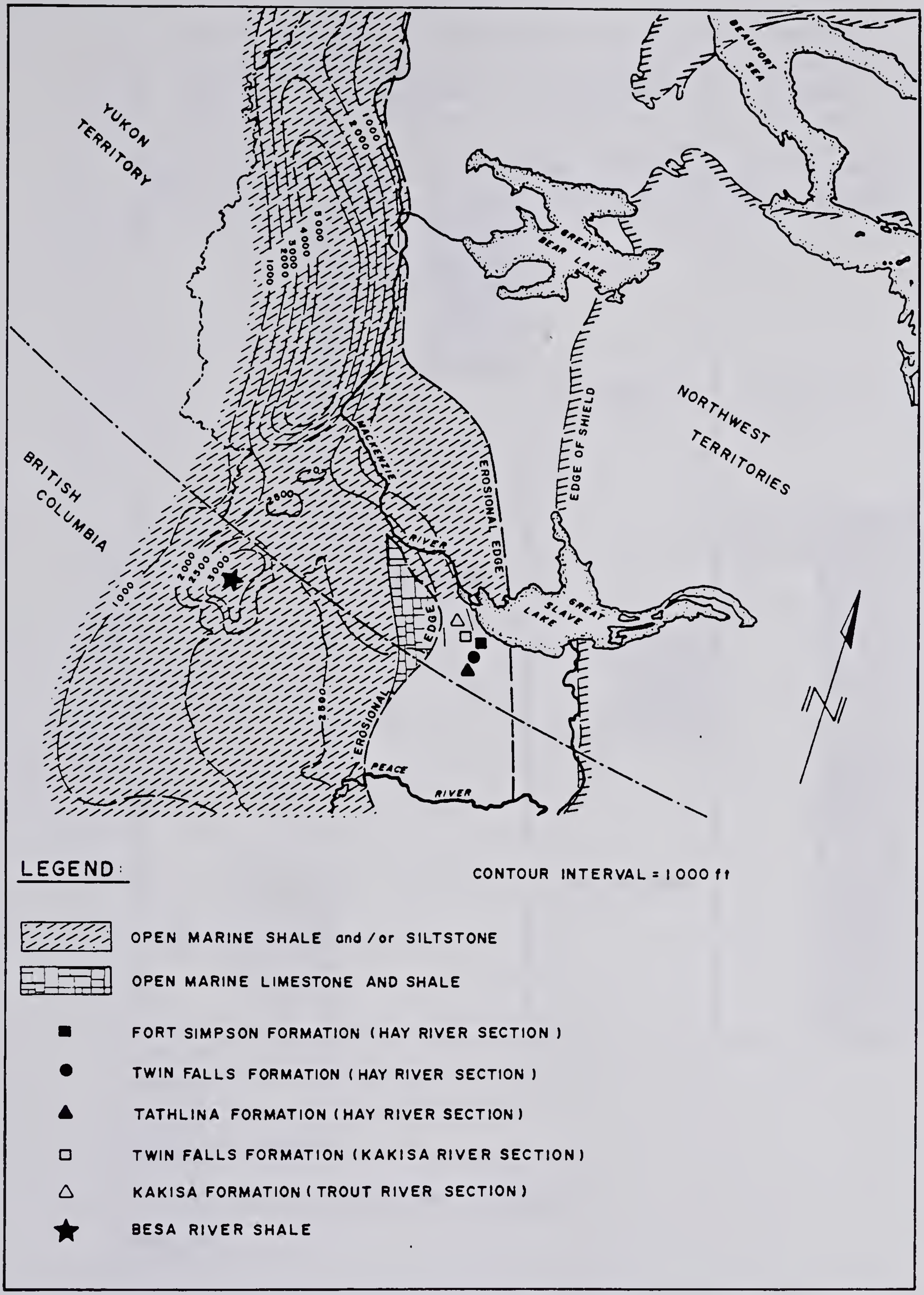


Fig. 7 - Isopach and facies map of northwestern, North America.

(adapted from Bassett and Stout, 1968)

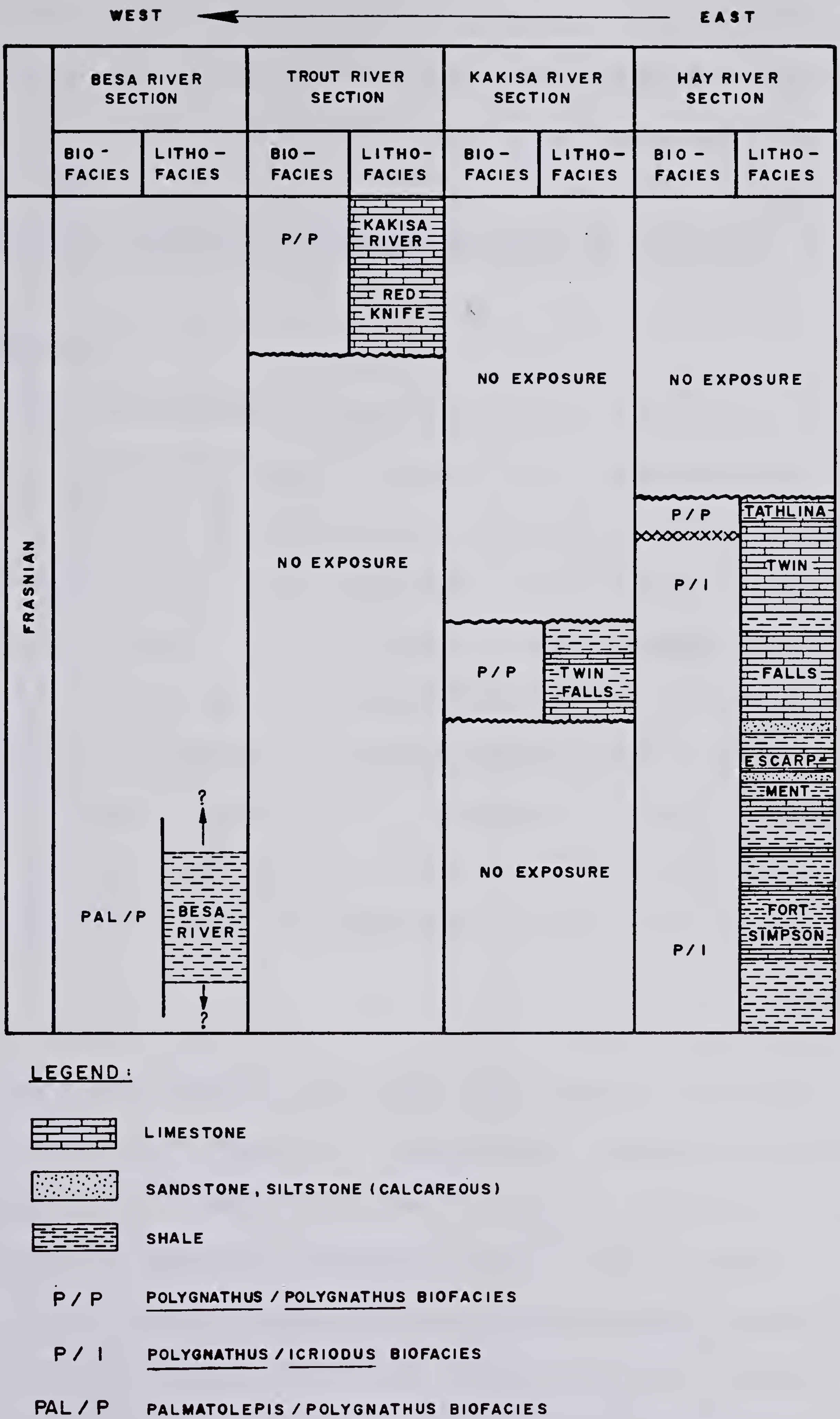


Figure 8 - Schematic representation of biofacies and lithofacies

Thus when considering conodont biofacies of Late Devonian age in the study area the environment can be considered to have been predominantly open marine. Fig. 7 is an isopach and facies map of the study area, after Bassett and Stout (1968), with the symbols designating particular sections and localities discussed in this work.

OBSERVATIONS

The paleoecological conclusions in this section are partly based upon data obtained during the course of this project, but they are mainly influenced by the following: previous work on the paleoecology of Devonian conodonts, and information as to the environmental preference of Devonian conodont taxa; the known paleogeography of the early part of the Late Devonian of Western Canada (in particular, direction of paleoshore and paleocontinental margin); and the relative distributions, geographic and stratigraphic, of gross lithologies (and their faunas) within the study area. The stratigraphy of this area was influenced by a transgression and regression during the Frasnian.

Recurrent associations of particular conodont taxa found in the study area are considered within this particular geographic and stratigraphic framework. Environmental preferences of particular associations of conodont taxa from this area are suggested from their expected environmental preferences (from the work of others).

Each collection representing a particular association was examined from the following points of view: its stratigraphic position in relation to this transgression and regression in the study area; and the expected environmental preferences of the taxa based on previous

work on Devonian conodont paleoecology.

The following associations of taxa are recognized: a *Polygnathus/Polygnathus* biofacies; and a *Polygnathus/Icriodus* biofacies. The *Polygnathus/Polygnathus* biofacies is dominated by various species of *Polygnathus*. The *Polygnathus/Icriodus* biofacies is dominated by species of *Polygnathus*, and has a significant quantity of *Icriodus*.

A summary of the observations made with regard to the study area are shown in Figure 8.

Polygnathus/Icriodus Biofacies

The *Polygnathus/Icriodus* biofacies is recognized in the Fort Simpson Formation and the Upper Member of the Twin Falls Formation at exposures along the Hay River in the eastern part of the study area, nearest to the paleo-shore. The Fort Simpson Formation contains the taxa *Mesotaxis asymmetrica ovalis* and *Ancyrodella rotundiloba*. Schumacher (1976) recognized a biofacies dominated by *Mesotaxis asymmetrica* and *Ancyrodella* spp., containing few specimens of *Icriodus*. This, he suggested, belonged to a deeper subtidal environment. Although some species characteristic of this biofacies are present, the formation is not dominated by them, and therefore cannot be considered as a similar biofacies. The Fort Simpson Formation is dominated by various species of *Polygnathus* and by *Icriodus* cf. *I. difficilis*. This association of taxa is close to that of Biofacies II of Druce (1973). Seddon and Sweet (1971), Druce (1973), Chatterton (1976) all assigned their biofacies with the common occurrence of *Icriodus* to a shelf environment.

Observation of the distributions in Table I makes it clear that

although Icriodus is never dominant, it is relatively abundant in the Fort Simpson Formation. In this formation, Icriodus is the second most abundant platform genus, next to Polygnathus. The ratio of Polygnathus to Icriodus is approximately 5:1. There are a number of species of Polygnathus: P. new species F, P. new species H, P. new species I, and P. xylus Stauffer.

The Twin Falls Formation, which consists predominantly of limestones, contains a Polygnathus/Icriodus association. This formation also contains Ancyrodella lobata. Ancyrodella has usually been considered to be part of Biofacies III, the Palmatolepis dominated biofacies (Seddon 1970, Seddon and Sweet 1971). If the Seddon and Sweet (1971) model is applied rigidly, it would be unusual to have forms characteristic of Biofacies III occurring in a sample dominated by forms belonging to Biofacies II.

The Twin Falls Formation has a diverse fauna which includes: Spathognathodus gradatus, Ancyrodella lobata, Polygnathus brevis, Polygnathus webbi, Polygnathus new species D, Polygnathus new species G, Polygnathus new species E, and Icriodus cf. I. difficilis. The ratio of Polygnathus to Icriodus in this sample is much higher than that of the Fort Simpson Formation, about 27:1. It is believed that this formation shows the beginning of the transition to the Polygnathus/Polygnathus biofacies.

Bassett and Stout (1968) considered the early Frasnian as a transgressive period, and that the sea encroached progressively further east. Therefore it would be expected that as transgression occurred that shallow water organisms would diminish at a particular locality. This is evident from observing the diminishing number of

icriodids in the Twin Falls Formation with respect to the Fort Simpson Formation; formations outcroping along the same section. Seddon (1970), and Seddon and Sweet (1971), only found Icriodus in near-shore facies, and close to the fore-reef facies of the shelf.

Polygnathus/Polygnathus Biofacies

The Polygnathus/Polygnathus biofacies is recognized in the Tathlina and Kakisa formations. The Tathlina Formation outcrops along the Hay River in the eastern part of the study area, and it lies conformably on the Twin Falls Formation. The Kakisa Formation, a formation stratigraphically higher than the Tathlina, outcrops along the Trout River, the most westerly section of the study area, and nearest to the Paleo-cratonic edge Douglas (1970).

The Tathlina Formation is dominated by species of Polygnathus, namely: P. new species D, P. new species E, P. brevis, and P. unicornis. Spathognathodus gradatus is also present and Icriodus is absent. Polygnathus new species D is the most abundant polygnathid in the samples.

The dwindling number of icriodids in the Twin Falls Formation, and the absence of Icriodus in the Tathlina Formation may be a response to the progressive transgression of the early Frasnian.

The Kakisa Formation is also dominated by species of Polygnathus, and it outcrops at the most westerly section of the study area. The Kakisa Formation was the beginning of the regressive phase of the Frasnian. This section is located nearer to the paleo-cratonic edge than the Hay River section (Douglas, 1970). In a few samples from this formation, the genus Palmatolepis was recovered, a genus usually

associated with the deeper slope facies. Since this section is near the paleo-cratonic edges, it is not surprising that rare forms characteristic of deeper biofacies may be present.

A collection of Frasnian conodonts from the Besa River Shale from northeastern British Columbia contains a typical Biofacies III association (material made available by B.D.E. Chatterton). Sandberg (1976), working with Famennian material, observed gradual change in his conodont faunas from faunas dominated by *Polygnathus* and *Icriodus* near the paleo-shore to faunas dominated by *Polygnathus* and *Palmatolepis* and finally to a *Palmatolepis*-bispathodid association farthest from the paleo-shore. (*Bispathodus* does not range down into the Frasnian).

Moving from the most easterly section along the Hay River, which was closest to the paleo-shore, to the Besa River Shale in northern British Columbia, farthest from the paleo-shore, there is a gradual shift from a *Polygnathus*/*Icriodus* association to a *Polygnathus*/*Polygnathus* association and then to a *Palmatolepis*/*Polygnathus* association (dominated by *Palmatolepis*).

The Escarpment Formation contains few conodont elements, and a very low diversity of species. The low diversity and quantity of elements could be the result of a change in the environment which made it less desirable for conodont habitation. The Escarpment Formation consists of some limestone, mudstone and sandstone. The limestone, where conodont samples were collected, contains an abundance of corals and brachiopods. It is puzzling that these limestone units in the Escarpment Formation have a relatively prolific macrofauna, but few conodonts. The presence of *Amphipora* and the absence of conodonts in these rocks may suggest that this unit was semi-restricted,

and that these are back-reef deposits. Seddon (1970) observed that conodonts are generally absent from back-reef facies.

The fauna of the Twin Falls Formation (Kakisa River), may be similar to those representative of the *Polygnathus/Polygnathus* biofacies. The formation at these localities, LK #1, LK #2, LK #3, consists predominantly of clastic deposits. Few conodonts were obtained from the Twin Falls Formation at the Kakisa River Section. *Ancyrodella lobata*, *Polygnathus* new species F, and *Polygnathus brevilaminus*, have all been recovered from this formation.

This section is west of the Hay River Section and shows some lateral changes from *Polygnathus/Icriodus* biofacies to a *Polygnathus/Polygnathus* biofacies, within the same formation, possibly related to proximity to shoreline.

CONCLUSION

Many of the polygnathid species observed in the study area have not been described by other workers. From this I conclude that these forms are not ubiquitous and probably have a limited geographic range. Although the genus *Polygnathus* is ubiquitous in distribution, it includes some species that were endemic to local regions. This indicates that these forms had a limited ability to disperse or are closely tied to specific environments that had limited geographic ranges. Conodonts may have been controlled by factors associated with depth or proximity to shoreline such as salinity and/or temperature. Observations pertaining to *Icriodus* suggest that this genus has a wide spread but patchy distribution. Species of *Icriodus* are generally more endemic than species of *Polygnathus*. In the study area,

Icriodus only occurs in the most easterly sections, those nearest the paleo-shore. *Icriodus* appears to become less abundant in the more transgressive phase of the sections. Seddon (1970) found *Icriodus* to be restricted to his shallow near-shelf facies in the Frasnian of Australia.

The distributions of the biofacies in the Hay River area, and in northeastern British Columbia, correspond closely to the interpretations made previously relating to the paleogeography.

SYSTEMATICS

Following Pander's original discovery of conodonts (1856), Hinde (1879) realized the multielemental nature of the conodont animal, and illustrated some fecal associations of conodont elements. He ascribed all his specimens to two genera, Prioniodus and Polygnathus. Although most of his groupings were incorrect, the concept of the multielement animal was correct. However, in the years that followed, most conodont workers ignored Hinde's idea and described and erected new genera and species based on observations of the distinctive morphology of individual elements, just as Pander had done in 1856.

Form taxonomy was a great success and aided in the development of conodont stratigraphy. Although these taxa were useful in biostratigraphy, they burdened conodont workers with a surplus of nomenclature.

In recent years Kohut (1969), Klapper and Philip (1971, 1972), Philip and McDonald (1975), Barrick and Klapper (1976), Sweet and Schönlaub (1975) amongst others, have reconstructed conodont apparatuses, either qualitatively or quantitatively. This development created new problems in the systematics of conodonts.

Some of the conodonts in the study area can be grouped into multielement taxa although other elements had to be left in their original form taxa, as a result of the present state of development of multielement taxonomy. Not all form elements can be associated with one another into multielement species because an inadequate number of multielement species have been recognized and reconstructed.

Among the more problematic elements in the study area are those elements belonging to the form genera *Lonchodina*, *Ligonodina*, *Hibbardella* and *Trichonodella*. The elements are recorded in the distribution tables as compound elements belonging to either a Type 1, Type 2 or Type 3 apparatus. Lack of sufficient quantities of these elements makes it impossible to determine any multielement association with confidence. Elements of this nature have been described as parts of the multielement genera *Parapolygnathus* or *Delotaxis* (Klapper and Philip, 1971). Sweet and Schönlaub (1975), working on Ordovician and Silurian material, described a multielement genus *Oulodus* (Branson and Mehl, 1933), with elements closely resembling some of the later Devonian material of the study area. They revised the diagnosis of *Oulodus* to include all the elements they believed associated, and also commented that *Delotaxis* may be synonymous with their multielement genus *Oulodus*, considering the similarity in apparatus structure. Although elements having an affinity to *Oulodus* or *Delotaxis* were recognized, any conclusions based on such a small number of elements would be speculative.

The only complete multielement species recognized is *Polygnathus webbi* Stauffer. Observation of the distributions of the component elements and the similarities in structure, size, robustness and the shape of the basal cavities of the constituents aided in the recognition of this multielement species. Part of the multielement species *Ancyrodella rotundiloba* (Bryant), as described by Klapper and Philip (1972), is recognized in the study area. Only the Pa and Pb elements of *Ancyrodella rotundiloba* were recovered.

Several form species of *Palmatolepis* were recovered but no other elements presumed to be associated with this form genus were found. Klapper and Philip (1972) considered *Palmatolepis* to be the Pa element belonging to one of their type apparatuses. They included the form genus *Palmatolepis* under the multielement genus *Palmatodella*. Philip and McDonald (1975) revised *Palmatodella* and suggested that the nothognathellan elements in the Pb position were not part of the *Palmatodella* apparatus. They postulated that a compound palmatodellan element is in the Pb position rather than a nothognathellan element. Since the various compound elements Philip and McDonald suggested to be associated with the palmatolepan elements in a multielement species were not recovered from the study area, the form genus *Palmatolepis* is retained in this study.

Polygnathan elements, such as *P. unicornis*, *P. brevis*, *P.* new species A, *P.* new species B, etc., are classified under the old form taxonomy since no association between these elements and ramiform elements can be positively determined. However, I believe that *P.* new species D, *P.* new species C, *P.* new species F, and *P. webbi* are closely related species, and had a similar multielement apparatus.

The form species *Spathognathodus gradatus* could belong to the multielement genus *Ozarkodina*.

Icriodus has always been a rather problematic genus. A species resembling *Icriodus difficilis* Ziegler, Klapper and Johnson was recovered from the Fort Simpson and Twin Falls formations. Only the form species is discussed in this chapter as no associated elements were recovered. Due to the variation in form exhibited by specimens from the study area, it became evident that the forms would be

difficult to identify. Therefore these specimens have been referred to as Icriodus cf. I. difficilis.

Many new species of Polygnathus were recovered from the formations in the thesis area. These species may be endemic to the region since they are associated only with open marine shelf deposits and have not been reported from elsewhere in North America. Several of these new species are very similar to one another and it appears that P. new species C, P. new species D, P. new species F, and P. webbi, may have had similar multielement apparatuses. P. new species F shows a great variation in oral ornament, from a fairly smooth surface to a ribbed surface. The ribbed forms could easily be mistaken for P. webbi, and the smoother forms of P. new species F appear to approach P. new species D. Note the variation in surface ornament in Plate 7, figs. 6, 7, 8, 12.

I suggest that P. webbi may have given rise to P. new species C. The deflections of these forms are similar; and the aboral views are almost identical. The blades of the elements are also very similar, and have 5 to 6 denticles fused together; the denticles increase in height anteriorly. The differences lie in the extent of the carina on the oral surface and the ribbing pattern.

It is also suggested that P. new species E may also be derived from P. webbi, or an immediate ancestor of P. webbi. P. new species E may have given rise to P. new species A. The development of the transverse ribbing on the tongue of P. new species E is very similar to that of P. new species A. In essence, the change that is required to give rise to P. new species A would simply involve the migration anteriorly of the posterior end of the carina. However, no forms were

found that are intermediate between P. new species E and P. new species A.

Although the evidence to support these hypotheses is limited, the relationships may still exist. These forms were apparently restricted in their geographical distributions and, with the exception of *Polygnathus webbi*, have not been reported elsewhere in North America. If they were geographically restricted to a region of what is now western or northwestern North America, the postulated relationships are more probable, since the possibility of immigration of taxa from other regions could be ruled out. (See Fig.9).

All multielement species reported in this thesis will be signified with the symbol MS behind the name. The terminology used is taken from Sweet and Schönlaub (1975). The equivalence of terminologies in different schemes used to demonstrate the homologies of elements in multielement associations, is shown in Table VII.

The occurrences in the following descriptions refer only to the study area.

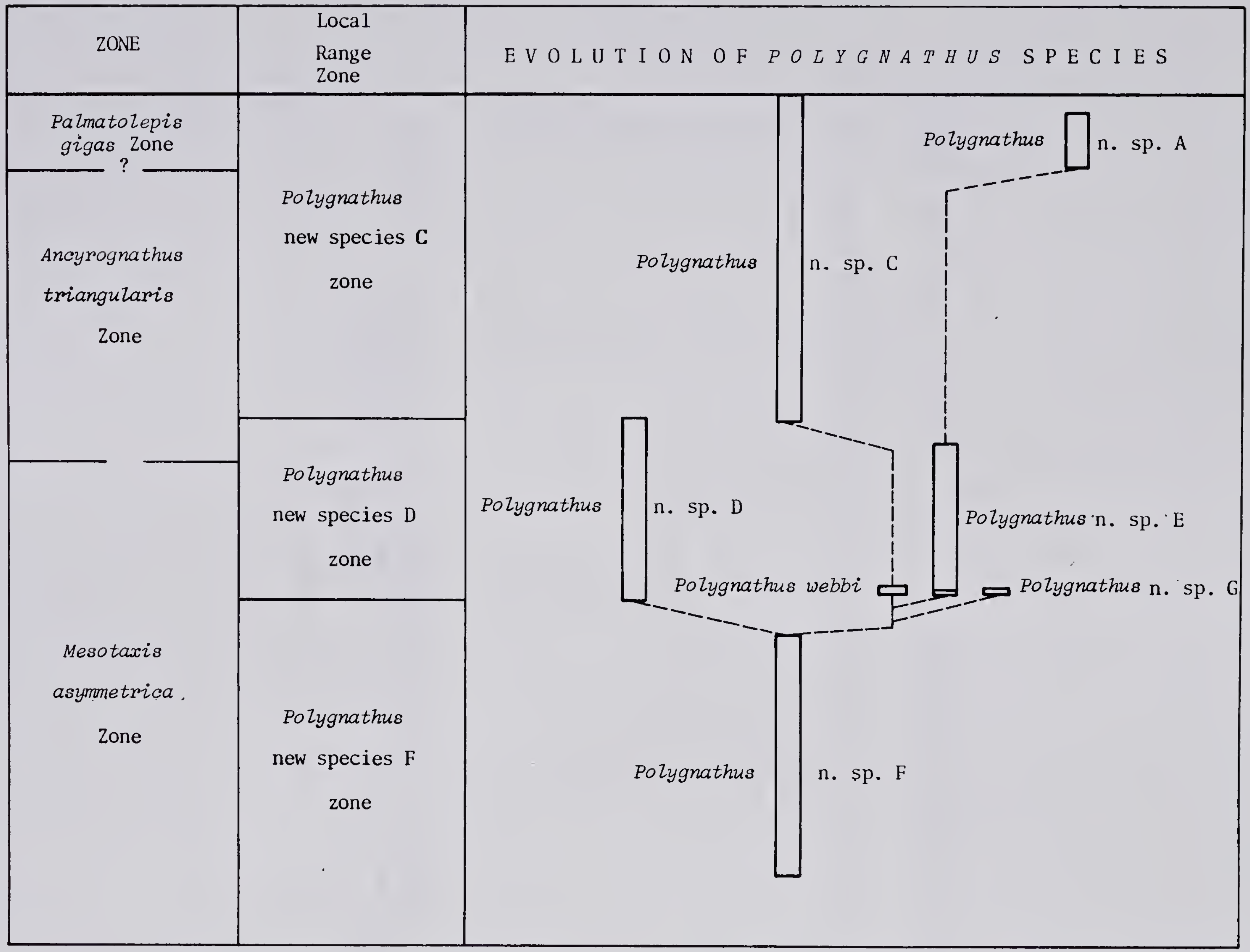


Figure 9 - Phylogenetic model for some species of <u>Polygnathus</u> in the study area

Klapper and Philip (1971)		Sweet and Schönlaub (1975)
Type 1	Type 2	
P	P	Pa
O_1	O_2	Pb
N	N	M
A_1	B_1	Sc
A_2	B_2	Sb
A_3	B_3	Sa

Table VII: Equivalence of terminologies used to describe homologies of elements in some multielement apparatuses of conodonts.

GENUS Ancyrodella Ulrich and Bassler, 1926

Remarks: The species belonging to this genus always have at least two secondary keels, and can have more. Müller and Müller (1957) suggested that these secondary keels were useful for generic determination but most workers (Glenister and Klapper, 1966, Anderson, 1966) do not consider the number of secondary keels as significant even at the specific level.

Klapper and Philip (1972) identified the elements associated with the form genus of Ancyrodella in a multielemental apparatus. They included the following elements in the multielement genus Ancyrodella: (Pa) ancyrodellan, (Pb) bryantodontan, (M) neoprioniodontan, (Sc-Sa) hindeodellan. Reconstructions of Ancyrodella as a multielement genus still must be proven to the satisfaction of most workers.

Ancyrodella lobata Branson and Mehl, 1933

Pl. 2, figs. 1 - 4, 7, 11, 12.

Ancyrodella lobata Branson and Mehl, 1933, pp. 239-240, Pl. 19, fig. 14, Pl. 21, figs. 22, 23. Miller and Youngquist, 1947, pp. 502-503, Pl. 74, figs. 10-12. Anderson,1966, p. 395, Pl. 41, figs. 15, 16. Seddon, 1970, Pl. 16, fig. 2.

Remarks: In samples from the Twin Falls Formation Ancyrodella lobata takes two basic forms. Some specimens have three secondary keels and others have two secondary keels. The ornament on the oral surface varies greatly. Forms with only two secondary keels may be mistaken for Ancyrodella nodosa, but the ornamentation on the oral surface is not as coarse and nodose.

A large bulk sample was studied to observe Ancyrodella lobata. The sample was collected from the same locality as HR #7, prior to my collection, and was made available to me by R.C. Fox. It is referred to in the plates as HR #7 (fish bed).

Range: Middle Mesotaxis asymmetrica Zone to lower Palmatolepis gigas Zone (Ziegler, 1971).

Occurrence: This species occurs in the Twin Falls Formation, where it outcrops along the Hay and Kakisa rivers.

Ancyrodella rotundiloba (Bryant, 1921) (MS)

Pl. 2, figs. 5, 6, 8, 9.

Polygnathus rotundiloba Bryant, 1921, pp. 26-27, Pl. 12, figs. 1-6, text-fig. 7.

Ancyrodella rotundiloba Müller and Clark, 1967, p. 908, Pls. 115, 116, text-fig. 6.

Bryantodus typicus Bassler, 1925, p. 219. Huddle, 1968, p. 11, Pl. 3, figs. 1-15, Pl. 4, figs. 12-15.

Remarks: Although the number of specimens derived from HR #3-base (54.9:180) and HR #3-9 (57.6:189) do not strongly indicate an association between the Pa and Pb elements, Bryantodus typicus has been identified as part of the Ancyrodella rotundiloba apparatus by Klapper and Philip (1972).

The Pa element of the species possesses large nodes. There exists, according to Müller and Clark (1967), a large variation in the form of this Pa element. The elements in the samples available to me all have their free blades broken, making identification difficult.

This species differs form Ancyrodella lobata, also found in the study area, in the oral ornament. The nodes are much larger than those of Ancyrodella lobata. Also there is indication that the specimens of Ancyrodella rotundiloba in the study area do not have as pronounced secondary keels as Ancyrodella lobata.

Range: Lower Mesotaxis asymmetrica Zone (Ziegler, 1971).

Occurrence: This species occurs 54.9 meters (180 ft.) to 57.6 meters (189 ft.) above the base of the Fort Simpson Formation.

GENUS *Ancyrognathus* Branson and Mehl, 1933

Remarks: Glenister and Klapper (1966) considered *Ancyrognathus* and *Ancyroides* as synonymous. The outline of the platform and the development of the blade is considered significant in species differentiation.

Ancyrognathus triangularis Youngquist, 1945

Pl. 2, fig. 10.

Ancyrognathus triangularis Youngquist, 1945, p. 356, Pl. 54, fig. 7. Glenister and Klapper, 1966, p. 800, Pl. 187, figs. 10-13. Anderson, 1966, pp. 395-415, Pl. 48, figs. 1, 5.

Remarks: Only one broken specimen was obtained, yet it was readily identified as *Ancyrognathus triangularis*. The angle between the inner lobe and secondary keel is close to 90°. The anterior portion of the specimen is missing.

Range: *Ancyrognathus triangularis* Zone to lower *Palmatolepis gigas* Zone (Ziegler, 1971).

Occurrence: The specimen occurs in sample TR #2 (20) which is 25 meters (82 ft.) above the base of the Kakisa Formation.

GENUS Apatognathus Branson and Mehl, 1933

Remarks: The genus consists of an arch which is asymmetrical to almost symmetrical. The denticles on the limbs may also trend in directions which make the form asymmetrical.

Apatognathus sp.

Pl. 5, figs. 12, 13.

Remarks: Only a few specimens of the form genus were recovered. This element has finely denticulated limbs in nearly perfect symmetry. It closely resembles Apatognathus varians Branson and Mehl, which Glenister and Klapper (1966) recovered from the Canning Basin. The denticles on the forms from the study area are much finer than those illustrated by Glenister and Klapper (1966). The Famennian forms identified by Pollock (1968) have little similarity to specimens from the study area. They are rather robust and very asymmetrical, unlike the apotognathids from the study area. The specimens from the study area are similar to the specimens of Apatognathus illustrated by Mound (1968). His Apatognathus porcata (Hinde) is quite close to the material from the study area, although the limbs appear to be slightly more robust.

Occurrence: It occurs in the Twin Falls Formation at the Hay River section and the Kakisa River section.

GENUS *Hibbardella* Bassler, 1925

Pl. 6, figs. 15, 16.

Remarks: *Hibbardella* is a robust form having a symmetrical anterior arch and a posterior bar. *Diplododella* closely resembles *Hibbardella*, but its anterior arch has a thinner blade. Both of these forms were probably derived from a trichonodellan element.

This form taxon is found in a number of multielement apparatus types. It is considered to be situated in the Sa position. Sa equates with the A_3 or B_3 position of Klapper and Philip (1971). Specimens belonging to this form genus are listed in the distribution tables as Sa elements belonging to either Type 1, Type 2, or Type 3 apparatuses.

GENUS *Hindeodella* Ulrich and Bassler, 1926

Pl. 6, figs. 8, 10.

Remarks: This form genus usually consists of a long posterior bar with a number of denticles and a shorter, usually curved, anterior bar. There is also a strong, long, main cusp. Generally this form genus occurs in the Sc position of a multielement apparatus. Specimens of this form genus are listed as Sc elements in the distribution tables.

GENUS *Icriodus* Branson and Mehl, 1938

Remarks: According to Klapper and Philip (1971, 1972) *Icriodus* is a multielement genus consisting of icriodonton (I) elements and acodinan (S_2) elements, making a type 4 apparatus. In this work no evidence was found to support this reconstruction.

The icriodonton element is easily recognized from other form genera. The Upper Devonian forms are difficult to identify at the species level because they are simple in form and highly variable.

Icriodus cf. *I. difficilis* Ziegler, Klapper and Johnson, 1976

Pl. 3, figs. 1-16.

Icriodus cf. *I. difficilis* Ziegler, Klapper and Johnson, 1976, pp. 117, 118, Pl. 1, figs. 1-7, 17.

Remarks: The numerous specimens observed show a great deal of morphological variation. The smaller specimens tend to have a large, fully-developed posterior blade. They begin to resemble *Icriodus brevis* Stauffer. The margins of the basal cavities of these smaller specimens are regular and bulbous in outline.

The posterior blade diminishes in size in the larger specimens and becomes the posterior cusp. The larger specimens take on the characteristic outline with an anterolaterally directed spur.

In order to study *Icriodus* cf. *I. difficilis* more closely a large bulk sample HR #7 (fish bed), made available to me by R. C. Fox, was studied. This sample is from the lower 20 meters of the Upper Member of the Twin Falls Formation. It corresponds with sample locality HR #7.

The writer believes the variation of this species of *Icriodus* to be ontogenetic and intraspecific. I could identify no criteria for differentiating the specimens into more than one species.

Range: *Mesotaxis asymmetrica* Zone to *Ancyrognathus triangularis* Zone, in the study area.

Occurrence: *Icriodus* cf. *I. difficilis* was recovered from between 54.9 meters (180 ft.) and 57.9 meters (190 ft.) above the base of Fort Simpson Formation. It was also found in the lower 35.6 meters (117 ft.) of the Twin Falls Formation.

Icriodus? sp.

Pl. 3, fig. 18.

Remarks: A broken anterior portion of a specimen believed to belong to *Icriodus*. This specimen clearly does not belong to the species described above.

Occurrence: It occurs 12.2 meters (40 ft.) above the base of the Trout River Formation on exposures along the Trout River.

GENUS <u>Ligonodina</u> Bassler, 1925

Pl. 6, figs. 5, 7, 9, 11, 14.

<u>Remarks</u>: Klapper and Philip (1971) considered this form genus to be an element belonging to the multielement genus <u>Delotaxis</u>. Sweet and Schönlaub (1975) included <u>Delotaxis</u> in the synonymy of their multielement genus <u>Oulodus</u>. This element is thought to be in the Sc position. A number of these elements was recovered from samples in the study area. Due to the small number of specimens, and lack of possibly associated taxa, it is impossible to erect a multielement species with these elements. They have been included in the tables under the heading "Elements belonging to Type 1, Type 2 or Type 3 apparatus", and listed as a Sc element, on Plate 6.

GENUS <u>Lonchodina</u> Bassler, 1925

Pl. 6, figs. 1 - 4, 6.

<u>Remarks</u>: This form genus was considered to be part of the multielement genus <u>Oulodus</u> (Sweet and Schönlaub, 1975). The positioning is variable depending on the shape, though it generally falls in a Sc or Pb position in the apparatus. The specimens figured on Plate 6 could each belong to a different multielemental species. <u>Lonchodina</u> elements have been included in the tables as Pb elements, of a Type 1, Type 2, or Type 3 apparatus.

GENUS Mesotaxis Klapper and Philip, 1972

Remarks: Klapper and Philip (1972) proposed this multielement genus. It is characterized by having (Pa) polygnathan, (Pb) nothognathellan, (M) palmatodellan or synprioniodinan, (Sc) falcodonton, (Sb) angulodontan, and (Sa) diplododellan elements. Later, Philip and McDonald (1975) revised the apparatus and stated that the Mesotaxis apparatus is characterized by Pa (polygnathid), Pb (ozarkadinan), M(lippertiform), Sc(hindeodellan), Sb(angulodontan), and Sa(diplododellan) elements.

Mesotaxis asymmetrica ovalis (Ziegler and Klapper, 1964)
Pl. 4, figs. 9, 10.

Polygnathus dubius Hinde, 1879, pp. 362, 363, Pl. 16, figs. 16, 18.
Polygnathus dubia dubia Bischoff and Ziegler, 1957, p. 88, Pl. 16, figs. 18, 19, Pl. 21, fig. 1.
Polygnathus asymmetrica ovalis Ziegler and Klapper in Ziegler, Klapper and Lindstrom, 1964, pp. 422-423. Uyeno, 1974, Pl. 3, figs. 2, 5, 7, Pl. 4, figs. 1, 3.

Remarks: This subspecies occurs in the lower part of the Fort Simpson Formation. Elements other than the Pa element of the Mesotaxis multielement apparatus were not identified in the Fort Simpson Formation.

Range: lower Mesotaxis asymmetrica Zone (Ziegler, 1971).

Occurrence: The species occurs in the Fort Simpson Formation at 57.6 meters (189 ft.) above its base along the Hay River.

GENUS <u>Microcoelodus</u> Branson and Mehl, 1933

<u>Remarks</u>: This form genus was used by Branson and Mehl (1933) to describe some conodonts consisting of a dominant medium cusp which is curved. The base is cupped and deep. At the base of the cusp, two small bars project, having denticles. Generally a ridge runs down the lateral surface of the main cusp.

This form genus is common in the Ordovician, but it is not as common in the Devonian.

<u>Microcoelodus?</u> new species A

Pl. 1, figs. 13 - 15.

<u>Diagnosis</u>: A form having one main cusp which is expanded at its base. The basal cavity has a moderate depth and is circular in outline. Bars with one or two denticles extend out laterally from the base.

<u>Description</u>: This form consists of one main cusp which is expanded near its base. The cusp has lateral carinae. The basal cavity is moderate in depth, with a circular outline. Bars with one or two denticles usually extend out laterally from the base. There is always at least one bar with a denticle.

<u>Remarks</u>: The affinities this form has with other Devonian conodonts are uncertain. It appears to have formed a multielemental apparatus of elements of similar but not identical morphology.

<u>Occurrence</u>: This form occurs near the base of the Tathlina Formation along the Hay River, and in the Kakisa Formation along the Trout River.

GENUS <u>Neoprioniodus</u> Rhodes and Müller, 1956

Pl. 6, figs. 12, 13, 17.

<u>Remarks</u>: <u>Neoprioniodus</u> is a form genus considered to take the M position in a multielement apparatus (Sweet and Schönlaub, 1976) or the N position of Klapper and Philip (1971,1972). This form genus is associated with many types (genera) of multielement apparatuses. These have been included under the M elements in the tables.

GENUS <u>Nothognathella</u> Branson and Mehl, 1933

Pl. 3, figs. 19-21.

<u>Remarks</u>: The difference between <u>Bryantodus</u> and <u>Nothognathella</u> is the presence or absence of a lateral platform. Generally, <u>Bryantodus</u> has no platform or a small platform. <u>Nothognathella</u> has a well-developed platform. It is clear from their appearance that these forms are homologous and may have a common origin. For example, <u>Nothognathella</u> is the Pb element in the multielement genus <u>Mesotaxis</u>. <u>Bryantodus</u> is the Pb element in the multielement genera <u>Hibbardella</u>, <u>Ancyrodella</u> and possibly others. This form is listed as a Pb element in the Fort Simpson Formation distribution table.

GENUS Palmatolepis Ulrich and Bassler, 1926

Remarks: This genus has been extremely useful in terms of zonation. Species are short-ranged and fairly readily recognized. The palmatolepids are rare in the rocks of the study area.

Klapper and Philip (1972) considered Palmatolepis to be the Pa element of their type 1 apparatus together with a nothognathelliform Pb element. Philip and McDonald (1975) reconstructed some possible multielement associations with Palmatolepis. They placed the form genus Palmatolepis in synonomy with the multielement genus Palmatodella, this being the initial form genus for Klapper and Philip's N element (Sweet and Schönlaub's M element). Although the reconstructions of Philip and McDonald (1975) may be correct, the palmatolepid material recovered from samples in the study area is sparse. The other elements recovered from the same sample can not be associated with the Palmatolepis elements. Since I believe that the existence of the multielement genus Palmatodella has not been unequivocally demonstrated, Palmatolepis is used in this study.

Palmatolepis gigas Miller and Youngquist, 1947

Pl. 4, fig. 12.

Palmatolepis perlobata (Ulrich and Bassler) Branson and Mehl, 1933 Pl. 18, fig. 24.

Palmatolepis flabelliformis Stauffer, 1938, pp. 411-443, Pl. 53, figs. 2, 9, 12, 14, non 4. Müller and Müller, 1957, pp. 1069-1108, Pl. 130, figs. 3-6.

Palmatolepis gigas Miller and Youngquist, 1947, pp. 501-517, Pl.75, fig. 1. Glenister and Klapper, 1966, pp. 777-842, Pl. 88, fig. 12.

Anderson, 1966, pp. 395-415, Pl. 49, figs. 1,2,4-10. Mound, 1968, Pl. 68, fig. 122. Pollock, 1968, Pl. 63, fig. 41.

Palmatolepis amana Müller and Müller, 1957, pp. 1069-1108, Pl. 140, fig. 5.

Remarks: The specimens of the genus obtained are small and therefore difficult to identify. The smaller specimens of Palmatolepis gigas and Palmatolepis subrecta are very similar. Because these small specimens are more similar to mature specimens of Palmatolepis subrecta they have been included in that taxon.

Some of the specimens are intermediate between Palmatolepis subrecta and Palmatolepis gigas. It is the author's opinion that the two are closely related and that the prominence of Palmatolepis gigas in the Palmatolepis gigas Zone is due to a morphological change from Palmatolepis subrecta to Palmatolepis gigas.

Range: Palmatolepis gigas Zone (Ziegler, 1973).

Occurrence: In the study area it is found in the upper 15 meters (49.2 ft.) of the Kakisa Formation.

Palmatolepis subrecta Miller and Youngquist, 1947

Pl. 4, figs. 13 - 15.

Palmatolepis subrecta Miller and Youngquist, 1947, pp. 501-517, Pl.75, figs. 7-11. Glenister and Klapper, 1966, pp. 777-842, Pl. 88, figs. 1-3. Anderson, 1966, pp. 395-415, Pl. 49, figs. 11-15, 17, 19. Pollock, 1968, Pl. 61, fig. 21.

Remarks: There are many gross similarities between Palmatolepis subrecta and Palmatolepis gigas, with some forms falling between

these two taxa (Ziegler, 1973).

Range: Upper *Mesotaxis asymmetrica* Zone to *Palmatolepis triangularis* Zone (Ziegler, 1971).

Occurrence: This species occurs near the top of the Kakisa Formation at exposures along the Trout River.

GENUS Polygnathus Hinde, 1879

Remarks: This is now regarded as a multielement genus having a Type 1 apparatus (Klapper and Philip, 1971), consisting of a platform (Pa) element, a hindeodellan (Sc) element, an angulodontan or plectospathodontan (Sb) element, a hibbardellan or diplododellan (Sa) element, an ozarkodinan (Pb) element and a neoprioniodontan or synprioniodontan (M) element. The platform elements all belong to the form genus Polygnathus. All species described in this section are of the form genus Polygnathus unless otherwise designated.

Polygnathus brevilaminus Branson and Mehl, 1933

Pl. 3, figs. 17, 22, 23, Pl. 5, fig. 6.

Polygnathus brevilamina Branson and Mehl, 1933, p.245, Pl. 21, figs.3-6.

Polygnathus brevilaminus Branson and Mehl. Szulczewski, 1971, pp. 46-47, 47, Pl. 18, figs. 5,6,10. Uyeno, 1974, pp. 37-38, Pl. 5, figs. 4,5.

Remarks: This species of Polygnathus is quite variable. Generally, it has a small platform with two or three small nodes on either side of the carina. It tends to have a high, large, free blade in the specimens observed in the study area.

Range: Mesotaxis asymmetrica Zone, in the study area.

Occurrence: This species only occurs in the Escarpment, and Twin Falls formations. There is a questionable occurrence in the Fort Simpson Formation.

Polygnathus brevis Miller and Youngquist, 1947

Pl. 4, figs. 1 -3, Pl. 5, figs. 3,4.

Polygnathus brevis Miller and Youngquist, 1947, p. 514, Pl. 74, fig. 9.
Polygnathus granulosa Branson and Mehl, Müller and Müller, 1957, p. 1088, Pl. 135, figs. 2,8, Pl. 141, fig. 1.

Remarks: Juvenile individuals have quite a different appearance from the larger forms (Pl. 5, figs. 3,4) though the basic pattern of the broad short platform, the nodes beginning to form on the posterior end and the size indicate that they are the same species.

Range: *Mesotaxis asymmetrica* Zone to the upper *Palmatolepis gigas* Zone (Ziegler, 1973).

Occurrence: The Twin Falls Formation, lower Tathlina Formation and the Kakisa Formation contain specimens of this species (See Tables III - VI).

Polygnathus unicornis Müller and Müller, 1957

Pl. 5, figs. 7 - 9.

Polygnathus unicornis Müller and Müller, 1957, p. 1089, Pl. 135, figs. 5, 6, Pl. 141, fig. 10. Ethington, 1965, Pl. 67, figs. 12, 16.

Remarks: On specimens observed from the Tathlina, Redknife and Kakisa formations, the carina consists of a ridge of fused denticles. The nodes on the oral surface vary in prominence, and are often fused, forming small ridges parallel to the carina. The crimp on the specimens observed is narrow, a characteristic of *Polygnathus unicornis*.

Range: *Ancyrognathus triangularis* to upper *Palmatolepis gigas* Zone (Ziegler, 1973).

Occurrence: This species was recovered from the Twin Falls, Tathlina, and Kakisa formations (See Tables III, V, VI).

Polygnathus webbi Stauffer, 1938 (MS)

Pl. 1, figs. 1-12.

Remarks on Synonymy: In this synonymy all the form species belonging to the multielement species are listed according to the types of elements designated by Sweet and Schönlaub (1975).

Pa elements

Polygnathus webbi Stauffer, 1938, p. 439, Pl. 53, figs. 25, 26, 28, 29. Miller and Youngquist, 1947, Pl. 74, figs. 1, 2. Uyeno, 1974, p. 4, Pl. 5, fig. 7.

Polygnathus normalis Miller and Youngquist. Glenister and Klapper, 1966, pp. 829-830, Pl. 95, figs. 6, 21, 22.

Pb elements

Ctenognathus elegans Stauffer, 1938, pp. 424-425, Pl. 48, figs. 9-12. Stauffer, 1940, p. 422, Pl. 59, figs. 3-5, 8.

Ctenognathus firmus Stauffer, 1938, p. 425, Pl. 48, figs. 4,7.

Ozarkodina elegans Stauffer. Sanneman, 1955, p. 133, Pl. 6, fig. 9. Ethington, 1965, p. 579, Pl. 68, fig. 15.

Sc elements

Hindeodella alternata Ulrich and Bassler, 1926, Pl. 12, figs. 14, 15. Müller and Clark, 1967, p. 913, Pl. 118, figs. 2,3. Seddon, 1970, Pl. 12, fig. 31.

Hindeodella mulleri Stauffer, 1938, p. 428, Pl. 50, figs. 1, 3a, b, 4, 9-11.

Hindeodella priscilla Stauffer, 1938, p. 429, Pl. 50, fig. 6.

Diagnosis: A multielement species of Polygnathus having Pa, Pb, M, Sc, Sb, and Sa elements. The Pa element is characterized by a mildly arched, slightly bowed, and keeled plate with a small shallow basal pit. The blade has a number of flattened denticles. An abundance of crossridging on the oral surface of the platform almost reaches the medial ridge or carina. The Pb element is ozarkodinan, consisting of a thin blade, slightly arched and bowed. There is a small basal pit at the bottom of the main cusp. The M element is a synprionodontan element. The bar is straight and arched. There is a deep pit under the main cusp. The basal cavity is also expanded under the main cusp. The anterior blade is small. The posterior blade is aborally deflected. The denticles on the posterior blade are small and variable in size. The Sc element is a thin hindeodellan element with a long posterior blade having alternating large and small denticles. The Sb element is thin with a similar denticle pattern to that of the Sc element, but the anterior blade is longer and not as strongly curved as that of the Sc element. The Sa element is a hibbardellan element. Its posterior blade is longer than either of the anterior lateral blades; the apical denticle is somewhat larger than the other denticles; and the blades are thin and fragile.

Remarks: The most characteristic element of this species is the Pa element. The other elements may be found associated with other polygnathan elements at different localities.

Range: Lower *Mesotaxis asymmetrica* to *Scaphignathus velifer* Zone (Ziegler, 1973).

Occurrence: It was recovered from the Twin Falls Formation, along the Hay River.

Polygnathus xylus Stauffer, 1940

Pl. 8, figs. 1-3.

Polygnathus xylus Stauffer, 1940, pp. 430-431, Pl. 60, figs. 54, 66, 72-74. Uyeno, 1974, pp. 40-41, Pl. 4, figs. 6,8.

Remarks: These forms are quite small and can easily be mistaken for juvenile forms of other polygnathids. This form species is either straight or deflected, but always slightly bowed. The carina extends the full length of the platform as a low ridge. The form is usually devoid of any ornament, and is smooth. The margins of the platform in some instances may be denticulated.

The blade is about half the length of the element and consists of eight to ten fused denticles, all relatively uniform in height.

The aboral surface has a narrow crimp and an expanded basal pit. There is a strong keel behind the basal pit, extending to the posterior tip of the platform.

Range: *Polygnathus varcus* to *Mesotaxis asymmetrica* Zones (Ziegler, 1973).

Occurrence: It occurs in the Fort Simpson Formation, 57.6 meters (189 ft.) above its base, along the Hay River.

Polygnathus new species A

Pl. 4, figs. 6-8,11.

Diagnosis: A Pa element having a strongly arched platform. The forms range from being straight to slightly bowed. The carina extends only a short distance posteriorly on the platform. The remainder of the platform is ornamented with transverse ridges which may be bowed medially backwards. The blade is very short, being only about one-sixth the length of the total element.

Description: This species is strongly arched and sometimes slightly bowed. The carina extends only a short distance posteriorly onto the platform. The adcarinal troughs are short as well and shallow. The platform is ornamented with transverse ridges which may be bowed medially backward. Anteriorly the transverse ridges grade into short ridges that run from the margin to the adcarinal trough.

This form has a short blade which consists of three or four fused denticles. The aboral surface has an extremely broad crimp with an anteriorly positioned, small, slightly flared basal pit. A low keel is present. Viewed from the top this species has a distinct fusiform shape.

Remarks: This form resembles the polylophodontids of Famennian age, but the difference lies in the ridge pattern. Polylophodontids have concentric ridges, not transverse ridges. This form may have been derived from Polygnathus new species E in that it has a similar ridge pattern at the posterior end of the platform. This transverse ribbing on the posterior tip also resembles the linquiformid polygnathids.

Range: Palmatolepis gigas Zone, in the study area.

Occurrence: This species is only found in the Kakisa Formation, ranging from the base to 33 meters (108 ft.) above the base of the formation

along the Trout River.

Polygnathus new species B

Pl. 7, figs. 4,5,9,10.

Diagnosis: A Pa element having a straight carina that extends the full length of the platform as a ridge. The inner and outer platforms are denticulated distally, and consist of sharp vertical ridges proximally. The margins are turned upwards. Deep adcarinal troughs extend the full length of the platform. The margins are irregular, and slightly convoluted.

Description: This species has a straight carina which extends the full length of the platform. The inner and outer platforms are denticulated distally and have sharp vertical ridges proximally. The margins are turned upwards. On either side of the carina run deep adcarinal troughs. The margins are twisted irregularly.

Aborally there is a well developed flared basal pit which is positioned medially on the element.

The blade consists of six to eight fused denticles and is about one-third the length of the platform.

Remarks: This is a readily distinguishable form and is unlike many polygnathids. The uniqueness of this form lies in the ornamentation of the inner and outer margins.

Range: *Palmatolepis gigas* Zone, in the study area.

Occurrence: They are found scattered in various samples collected from the Kakisa Formation ranging from 25 to 53 meters above the base of the formation.

Polygnathus new species C

Pl. 8, figs. 4-6,13,18,19.

Diagnosis: Pa elements with platform and carina that are slightly deflected inward at the posterior end of the element. Oral ornament consists of sub-transverse ridges at the very posterior tip of platform and grades anteriorly into short ridges that run inward and slightly backward from the margins. The carina extends two-thirds to three-quarters of the length of the platform. The anterior portion of the carina is fused into a low ridge, and the posterior portion of the carina consists of fused but distinct nodes.

Description: This species is slightly arched and bowed. The platform and carina are deflected inwardly from the blade at an angle ranging from 25^{o} to 30^{o} at the posterior end of the element. On the oral surface, the carina extends posteriorly two-thirds to three-quarters of the length of the platform. Ornament consists of sub-transverse ridges crossing the posterior tip of the platform and then grades into lateral ridges anteriorly running inward and backward from the margins of the platform. In some cases the ridges on the posterior tip of the platform diffuse into small nodes. A feature shown in some specimens is an outer platform which is flared near its midlength. Generally the platform is broad and the margins are not high. On the oral surface of the margins of the platforms a cellular micro-ornament is visible (Pl. 8, fig.19).

The blade is high posteriorly and consists of six to eight fused denticles. It ranges from one-third to one-half the length of the total element.

The margins of the platform have upturned edges anteriorly. Ornament also decreases anteriorly, to where the margins are smooth.

These forms have a broad crimp, and a small basal pit. A well pronounced keel is present behind the basal pit, extending to the posterior tip.

Remarks: Compound elements believed to be associated with the platform elements indicate that this form probably belongs to a Type 1 apparatus of Klapper and Philip (1971). It is interesting to note that the compound elements believed associated with this form are similar, if not the same as, those described under *Polygnathus webbi* Stauffer.

The platform element shows some similarity to both *Polygnathus webbi* and *Polygnathus* new species G. The basal views of these three platform elements are very similar. The compound elements that may be associated with these platform elements in multielement taxa are also very similar, suggesting a close relationship between these taxa (See Figure 9).

Range: *Ancyrognathus triangularis* to *Palmatolepis gigas* Zone, in the study area.

Occurrence: This form occurs throughout the Kakisa Formation, from the base to the top of the formation along the Trout River.

Polygnathus new species D

Pl. 5, figs. 1,2. Pl. 8, figs. 7-9, 14-16.

Diagnosis: This polygnathid is gently arched, and ranges from straight to slightly bowed in shape. The oral surface is characteristically devoid of any ornament and is smooth. The carina extends the full length of the platform to the posterior tip as a uniform ridge or row of nodes.

Description: A species of Polygnathus which has a narrow, straight to slightly bowed platform. The carina extends as a ridge to the posterior tip of the platform. The lateral margins of the platform are smooth. The species is devoid of any oral ornament. The aboral side has a narrow crimp and a small shallow basal pit. The slope between the margin of the platform and the adcarinal trough is steep. This adds to the generally narrow appearance of this form. The blade of this form ranges from one-third to one-half the length of the total element and consists of six to eight fused denticles.

Remarks: In samples where an abundance of this species was recovered, compound elements similar to those associated with Polygnathus webbi were observed. The co-occurrence and numerical quantities indicate that these elements may belong to Polygnathus new species D. Although this was observed, not enough samples were studied to be confident in the association.

It is suggested here that Polygnathus new species D was derived from Polygnathus new species F. This suggestion is supported by the variation in ornament of Polygnathus new species F. Some forms are very smooth and begin to approach a shape that could be assigned to

Polygnathus new species D. This form resembles forms that Uyeno (1974) described as Polygnathus incompletus Uyeno. Polygnathus new species D differs from Polygnathus incompletus in being larger, and having a carina that reaches the posterior tip of the element.

Range: Middle Mesotaxis asymmetrica Zone to Ancyrognathus triangularis Zone, in the study area.

Occurrence: The Twin Falls and Tathlina formations contain many specimens of this taxon, along exposures of the Hay River.

Polygnathus new species E

Pl. 7, figs. 1-3.

Diagnosis: A Pa element having a long narrow platform which is arched and slightly deflected inward near the midlength of the platform. On the oral surface there are well developed ridges which posteriorly form transverse ridges which cross the tip of the platform. The carina extends about two-thirds the length of the platform in the form of small nodes. The adcarinal groove is only present anteriorly and gradually disappears posteriorly. The margins are not upturned posteriorly and are weakly upturned anteriorly.

Description: This species has a long narrow platform which is arched and deflected near the midlength of the platform. Ornament on the oral surface consists of transverse ridges that cut across the posterior tip of the platform and lateral sub-perpendicular ridges anteriorly. A carina extends about two-thirds of the way along the platform and disappears towards the posterior tip. It consists of small nodes for most of its length. Anteriorly these nodes are fused to form a low

ridge.

The blade is about one-third the length of the total element and consists of eight or nine fused denticles.

The aboral side of the element has a broad crimp and a very small basal pit. It has a low keel.

Remarks: This form probably was derived from a form close to *Polygnathus webbi*. The transverse ribbing on the posterior tip of the platform is very much like that of a linquiformid polygnathid. There also appear to be affinities to *Polygnathus* new species A, which may be a derivative of this form.

Range: *Mesotaxis asymmetrica* to *Ancyrognathus triangularis* zones, in study area.

Occurrence: It occurs in the Upper Member of the Twin Falls Formation and the bottom of the Tathlina Formation along the Hay River section.

Polygnathus new species F

Pl. 7, figs. 6-8,12,13.

Diagnosis: A Pa element which is slightly arched and deflected at the midlength of the platform. The carina extends the full length of the platform; anteriorly it forms a low ridge and posteriorly it consists of distinct denticles. Anteriorly the margins of the platform are turned upward. Ornament consists of small sub-perpendicular ridges, and is most prominent at the posterior end of the platform. Ornament tends to diminish anteriorly. The posterior portion of the platform is usually expanded.

Description: This species is slightly arched and deflected. The angle of deflection from the blade is usually between 15^{o} and 20^{o}. The carina extends the full length of the platform, and anteriorly forms a low ridge and posteriorly consists of a row of distinct nodes. The transformation of the carina to nodes is usually at the point of deflection. Most specimens show ornament on the posterior portion of the platform. It consists of small sub-perpendicular ridges. Anteriorly, the ornament diminishes. Some specimens, although rare, are devoid of any ornament. There seems to be a fairly large variation in the amount and type of ornament, from forms with little or no ornament to forms with strong ribbing. The extremes are rare. Generally the margins are turned upward anteriorly.

The blade is about one-third the length of the element, and consists of six to eight fused denticles.

The aboral surface shows a broad crimp and a relatively shallow and small basal pit. A well developed keel extends from the basal pit to the posterior end of the element.

Remarks: This species may be ancestral to *Polygnathus webbi*. Many specimens begin to show a ribbing pattern similar to that of the P elements of *Polygnathus webbi*, although it is not as well pronounced. The variation in the ornament of this form, from very little ornament to well pronounced ribbing suggests that it may have given rise to both *Polygnathus webbi* and *Polygnathus* new species D.

This species differs from the types of *Polygnathus webbi* Stauffer (1938) in that its ribbing is not as pronounced. Some specimens are nearly smooth, except near the posterior tip of the platforms.

Range: *Mesotaxis asymmetrica* Zone, in the study area.

Occurrence: It occurs in the Fort Simpson Formation, about 57 meters (187 ft.) above the base of the formation, at the Hay River section.

Polygnathus new species G

Pl. 4, figs. 4,5.

Diagnosis: A Pa element with a platform and carina that are slightly deflected posteriorly. The carina extends the full length of the platform, and characteristically diffuses into a row of individual nodes posteriorly. Anteriorly the carina forms a low narrow ridge. Posteriorly the margins of the platform are serrated, and anteriorly weakly serrated. Medially the margins are smooth. The oral surface is predominantly smooth.

Description: The platform and carina are slightly deflected posteriorly. The carina extends the full length of the platform. Posteriorly it takes the form of four or five distinct nodes; and anteriorly the nodes are fused to form a low ridge. The margins of the platform are smooth medially but distinctly denticulated or serrated posteriorly, and weakly serrated anteriorly. The inside platform does not extend as far forward as the outer platform.

The blade ranges from one-quarter to one-third the length of the element and consists of about six fused denticles.

The aboral surface has a well developed crimp, with a small but distinct basal pit, towards the anterior end of the platform. Behind the basal cavity is a well developed keel.

Remarks: Although few specimens were recovered it is a very distinct form. It is interesting to note that the aboral view of this platform species is similar to those of both *Polygnathus webbi* and *Polygnathus* new species C. The oral surface is very smooth, and is similar to that of *Polygnathus* new species D. The difference between *Polygnathus* new species D and *Polygnathus* new species G is the serrated margins of the latter form. The platform of *Polygnathus* new species D has smooth margins.

The manner in which the carina diffuses into individual nodes posteriorly is similar to that of *Polygnathus* new species F. *Polygnathus* new species F always has some oral ornament even if it is weak, unlike that of *Polygnathus* new species G.

Range: *Mesotaxis asymmetrica* Zone, in the study area.

Occurrence: It occurs in a sample 35 meters (115 ft.) above the base of the Twin Falls Formation, along the Hay River.

Polygnathus new species H

Pl. 7, figs. 11,14,15.

Diagnosis: A Pa element being slightly bowed and arched. The carina extends the full length of the platform as a narrow ridge. The oral ornament consists of coarse sub-perpendicular ridges that run from the margins to the adcarinal trough. The margins of the platforms are irregular, and in lateral profile often appear serrated. The posterior tip of the platform is pointed.

Description: This species is slightly bowed and arched. The posterior tip of the platform is usually pointed. The carina extends as a narrow

ridge, the full length of the platform. Oral ornament consists of coarse sub-perpendicular ridges which run from the margins to the ad-carinal trough. The outer margins of the platform are usually quite irregular.

The blade increases in height anteriorly and consists of six to eight fused denticles.

The species has a broad crimp on the aboral side and a shallow elongated basal pit. A low keel extends posteriorly from the basal pit.

Remarks: *Polygnathus* new species H differs greatly from most of the forms in the thesis area. The margins are irregular, unlike those of *Polygnathus webbi*. The ribbing is somewhat similar in appearance. The form is usually long and narrow and the platform does not broaden posteriorly as in *Polygnathus webbi*.

This form is quite different from *Polygnathus decorosus* Stauffer. *P. decorosus* tends to have upturned margins anteriorly, unlike *P.* new species H. The margins are also more regular than the *P.* new species H.

Range: *Mesotaxis asymmetrica* Zone, in the study area.

Occurrence: It occurs in the Fort Simpson Formation.

Polygnathus new species I

Pl. 8, figs. 10-12.

Diagnosis: This Pa element is slightly arched and deflected inwardly. The form is narrow and long. The anterior portions of the margin are upturned. The carina extends the full length of the platform as a low ridge, becoming distinct denticles at the posterior tip. The oral

ornament consists of sub-perpendicular ridges that extend from the margins to the adcarinal troughs.

Description: This species is long and narrow, and is slightly arched and deflected. The oral ornament consists of sub-perpendicular ridges that run from the margins to adcarinal troughs. The carina extends the full length of the platform. The margins are up-turned anteriorly in the larger, presumed adult, forms. Smaller forms have the margins up-turned further posteriorly. Oral ornament is also less prominent on smaller forms.

The blade is quite long also, having denticles of a uniform height. There are usually nine or ten fused denticles.

The aboral surface has a narrow crimp and a small basal pit. A low keel extends posteriorly from the basal pit.

Remarks: This form resembles *Polygnathus webbi* in the oral ornament. The ribbing is very similar. The form is long and narrow which is unlike *Polygnathus webbi*. The anteriorly up-turned margins are quite common in many polygnathids and are exhibited in *Polygnathus webbi*, *Polygnathus* new species F, and *Polygnathus* new species C in the study area. *Polygnathus* new species C and *Polygnathus* new species F exhibit variations in oral ornament and length to width ratios that are not similar to *Polygnathus* new species I. The platforms of *P.* new species C and *P.* new species F are broader than that of *P.* new species I. The smaller forms of this new species are not as ornamented, with ribbing, although margins are still up-turned anteriorly.

Range: *Mesotaxis asymmetrica* Zone, in the study area.

Occurrence: This species occurs in the Fort Simpson Formation on exposures along the Hay River.

Polygnathus sp. 1

Pl. 5, fig. 5.

Remarks: A broken specimen of *Polygnathus*, with a thick narrow platform, a carina consisting of nodes, and ornament on the platform consisting of small nodes and transverse ridges. This specimen cannot be included in any of the species of *Polygnathus* described above, but is too incomplete to describe as a new taxon.

Occurrence: This form was found in the Trout River Formation in the exposures along the Trout River.

GENUS *Spathognathodus* Branson and Mehl, 1941

Remarks: A spathognathodan element is the Pa element of one of the following multielement genera: *Ozarkodina* or *Pandorinellina*. The particular genus it belongs to depends on the Sa element. *Pandorinellina* has a diplododellan Sa element and *Ozarkodina* has a trichonodellan Sa element. The elements described under the form genus *Spathognathodus* in this work are those whose associations are uncertain.

Spathognathodus gradatus (Youngquist, 1945)
Pl. 1, figs. 16,17.

Mehlina gradata Youngquist, 1945, p. 363, Pl. 56, fig. 3.

Mehlina irregularis Youngquist, 1945, p. 363, Pl. 56, fig. 2.

Ctenognathus gradatus (Youngquist) Müller and Müller, 1957, p. 1083, Pl. 135, figs. 10,11.

Spathognathodus gradatus (Youngquist) Szulczewski, 1971, p. 55, Pl. 20, figs. 1, 6-8. Uyeno, 1974, pp. 41,42, Pl. 8, figs. 1, 15-18.

Remarks: There is some variation in the denticulation on the blade. A few specimens show very small denticles or nodes on the lateral edges of the blade (See Pl. 1, fig. 17).

Range: *Mesotaxis asymmetrica* Zone to *Palmatolepis gigas* Zone.

Occurrence: In the study area, this species occurs in the Kakisa, Tathlina, and Twin Falls formations, in exposures along the Hay River, Kakisa River and Trout River.

Spathognathodus cf. *S brevis* Bischoff and Ziegler, 1957

Pl. 8

cf. *Spathognathodus brevis* Bischoff and Ziegler, 1957, pp. 116-117, Pl. 19, figs. 24,27-29.

Remarks: This form differs somewhat from *Spathognathodus brevis* Bischoff and Ziegler in that it does not have the largest denticle directly above the basal pit. Other than that the form is very similar.

Range: *Mesotaxis asymmetrica* Zone?

Occurrence: It was recovered from one sample HR #6-20, in the Escarpment Formation.

GENUS *Trichonodella* Branson and Mehl, 1948

Pl. 5, figs. 10,11.

Remarks: A form genus consisting of an anterior arch with a nondenticulate posterior extension or expansion. This form is included in the distribution tables as an Sa element.

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A P P E N D I X

Plates 1 - 8

PLATE 1

All magnifications X60 unless otherwise stated.

Figs. 1 - 12.	Polygnathus webbi Stauffer . (1) oral view of Pa element. (2) lateral view of Pa element. (3) aboral view of Pa element. (4,5) Pb element. (6) Sa element. (7) Sb element. (8.9) M element. (10) Sa element. (11) Sc element. (12) Sc element. Specimens from Twin Falls Formation sample (HR#7-18').
Figs. 13,14,15.	Microcoelodus?new species A. (13) 30X. Specimens from Twin Falls Formation sample (HR#1-1 1/2).
Figs. 16,17.	Spathognathodus gradatus (Youngquist). (16,17) side view. Specimens from Twin Falls Formation. (16) sample (HR#7-35). (17) sample (HR#7-13').

REPOSITORY

Figs. 1 - 17	U. of A. 3401 - 3417

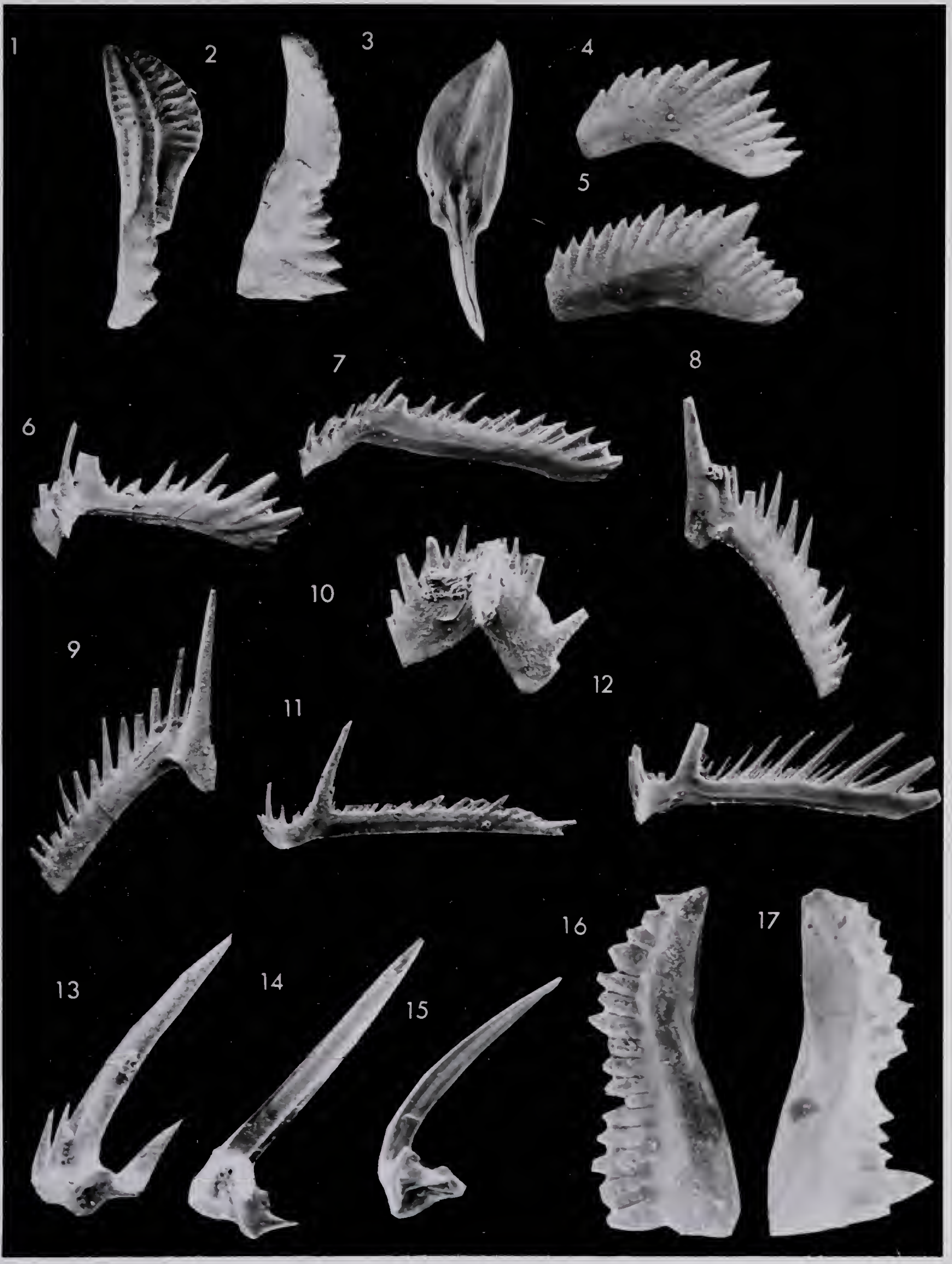
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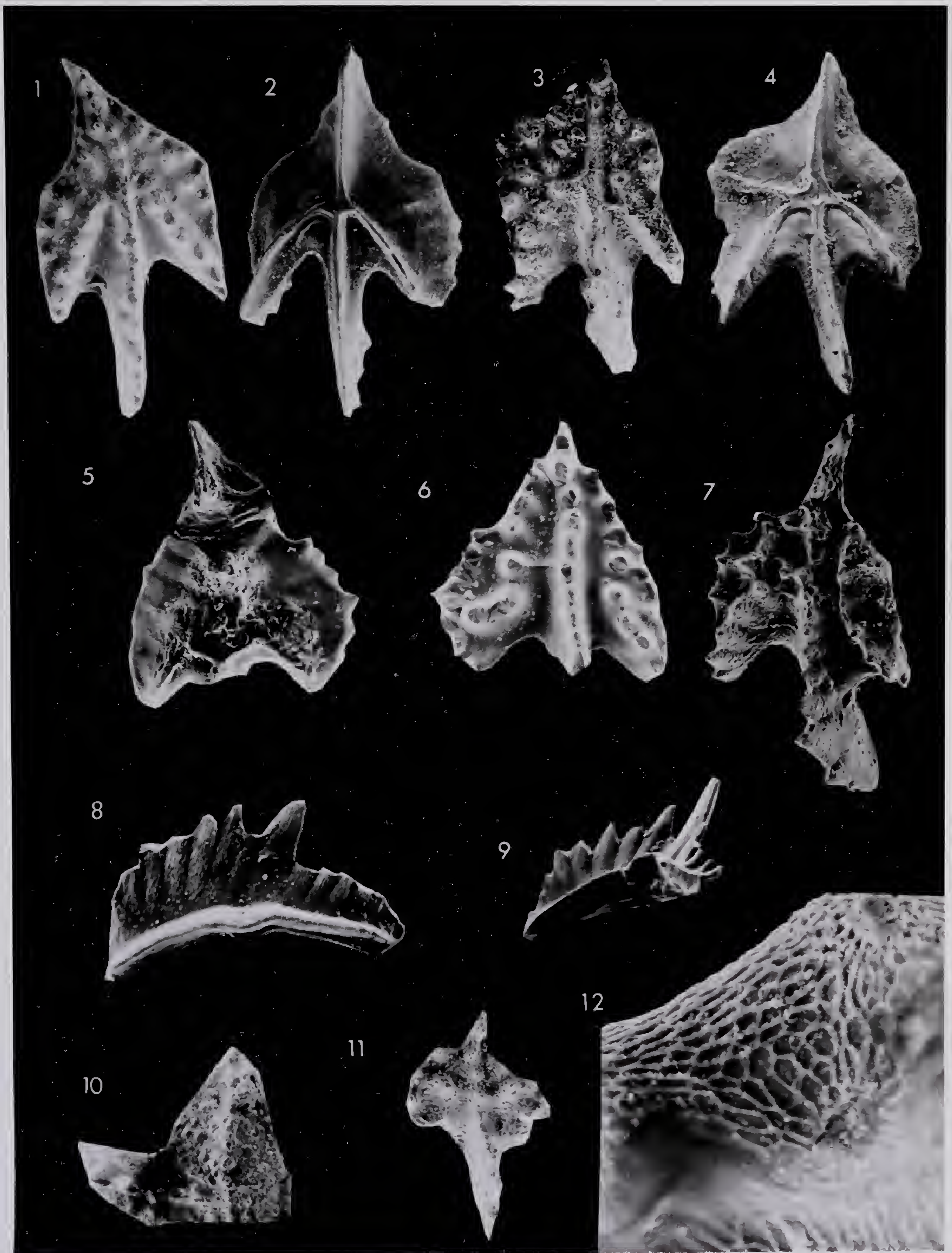
PLATE 2

All magnifications X60 unless otherwise stated.

Figs. 1 - 4,7,12.	Ancyrodella lobata Branson & Mehl . (1,3) oral view. (2,4) abotal view. (7) oral view 120X. (12) oral surface 600X. Specimens from Twin Falls Formation sample (HR#7-fish bed).
Figs. 5,6,8,9.	Ancyrodella rotundiloba (Bryant). (5) aboral view of Pa element. (6) oral view of Pa element. (8) Pb element 30X. (9) Pb element. Specimens from Fort Simpson Formation sample (HR#3-9).
Fig. 10.	Ancyrognathus triangularis Youngquist . (10) oral view. Specimen from Kakisa Formation sample (TR#2-20').
Fig. 11.	Ancyrodella lobata (juvenile) (11) oral view. Specimen from Twin Falls Formation sample (HR#7-fish bed).

REPOSITORY

Figs. 1 - 11	U. of A. 3418 - 3428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P L A T E 3

All magnifications X60 unless otherwise stated.

Figs.	1 - 16.	Icriodus cf. I. difficilis Ziegler, Klapper & Johnson. (1,3,5,7,9,11,13,14,15) Oral view. (2,4,6,8,10,12,16) Aboral view. Specimens from Twin Falls Formation sample (HR#7-fish bed).
Figs.	17,22,23.	Polygnathus brevilaminus Branson & Mehl. Specimens from Twin Falls Formation sample (LK#2-20')
Fig.	18.	Icriodus sp. (18) 120X, oral view. Specimens from Trout River Formation sample (TR#4-40').
Figs.	19,20,21.	Nothognathella bicristata Miller & Youngquist. (19,20) Side view 30X. (21) Oral view. Specimens from Fort Simpson Formation sample (HR#3-9')

REPOSITORY

Figs.	1 - 23	U. of A. 3429 - 3451

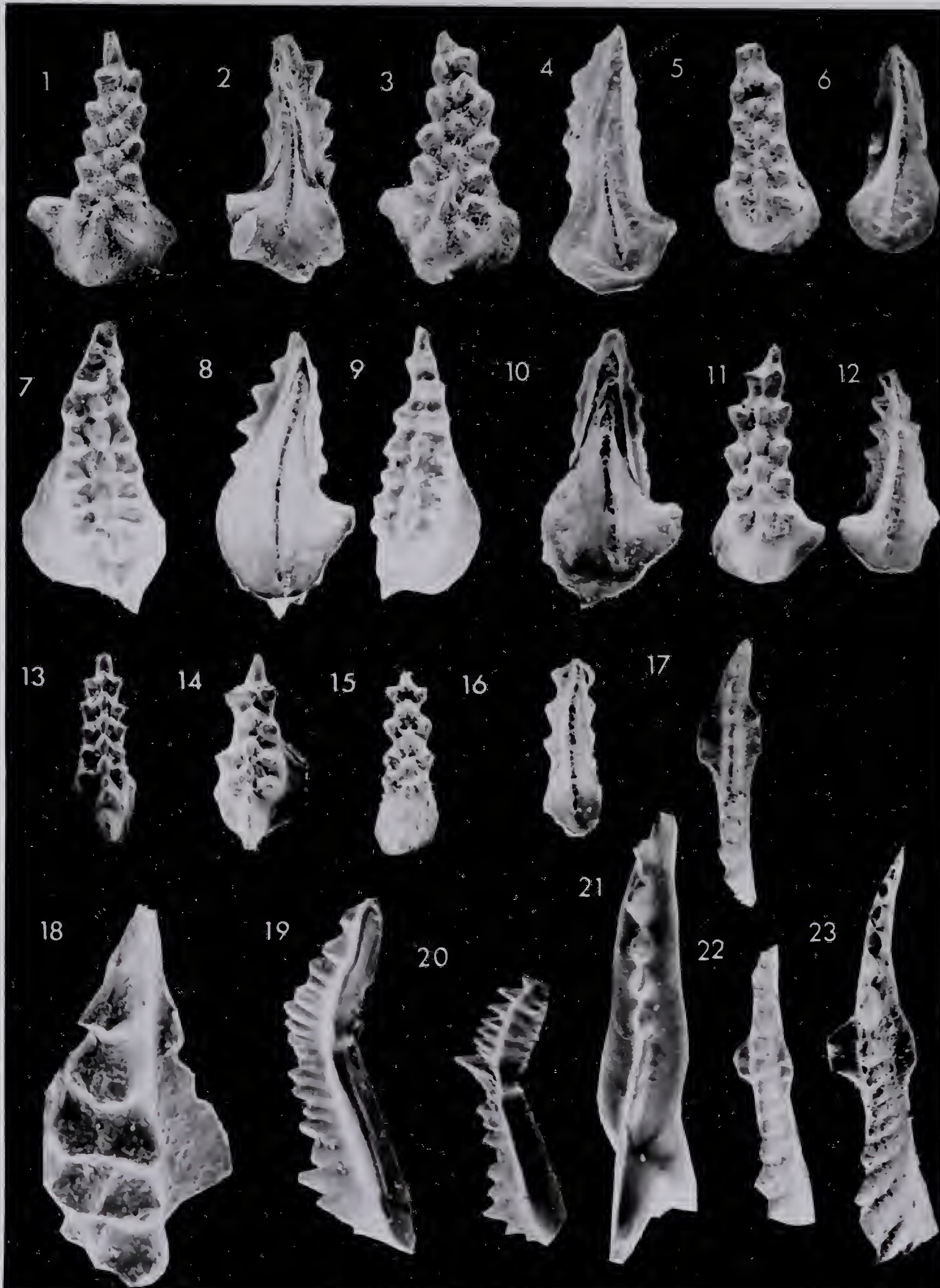

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PLATE 4

All magnifications X60 unless otherwise stated.

Figs.	1 - 3.	Polygnathus brevis Miller & Youngquist. (1,3) Oral view. (2) Aboral view. Specimens from Tathlina Formation sample (HR#1-5')
Figs.	4,5.	Polygnathus new species G. (4) Aboral view. (5) Oral view. Specimens from Twin Falls Formation sample (HR#7-13').
Figs.	6 - 8,11.	Polygnathus new species A (6) Side view. (7,11) Oral view. (3) Aboral view. Specimens from Kakisa Formation sample (TR#3-base).
Figs.	9,10.	Mesotaxis asymmetricus ovalis (Bischoff & Ziegler). (9) Oral view. (10) Aboral view. Specimens from Fort Simpson Formation sample (HR#3-9').
Fig.	12.	Palmatolepis gigas Miller & Youngquist. (12) Oral view. Specimen from Kakisa Formation sample (TR#1-5').
Figs.	13 - 15.	Palmatolepis subrecta Miller & Youngquist. (13 - 15) Oral view. Specimens from Kakisa Formation sample (TR#1-5').

REPOSITORY

Figs. 1 - 15 U. of A. 3452 - 3466

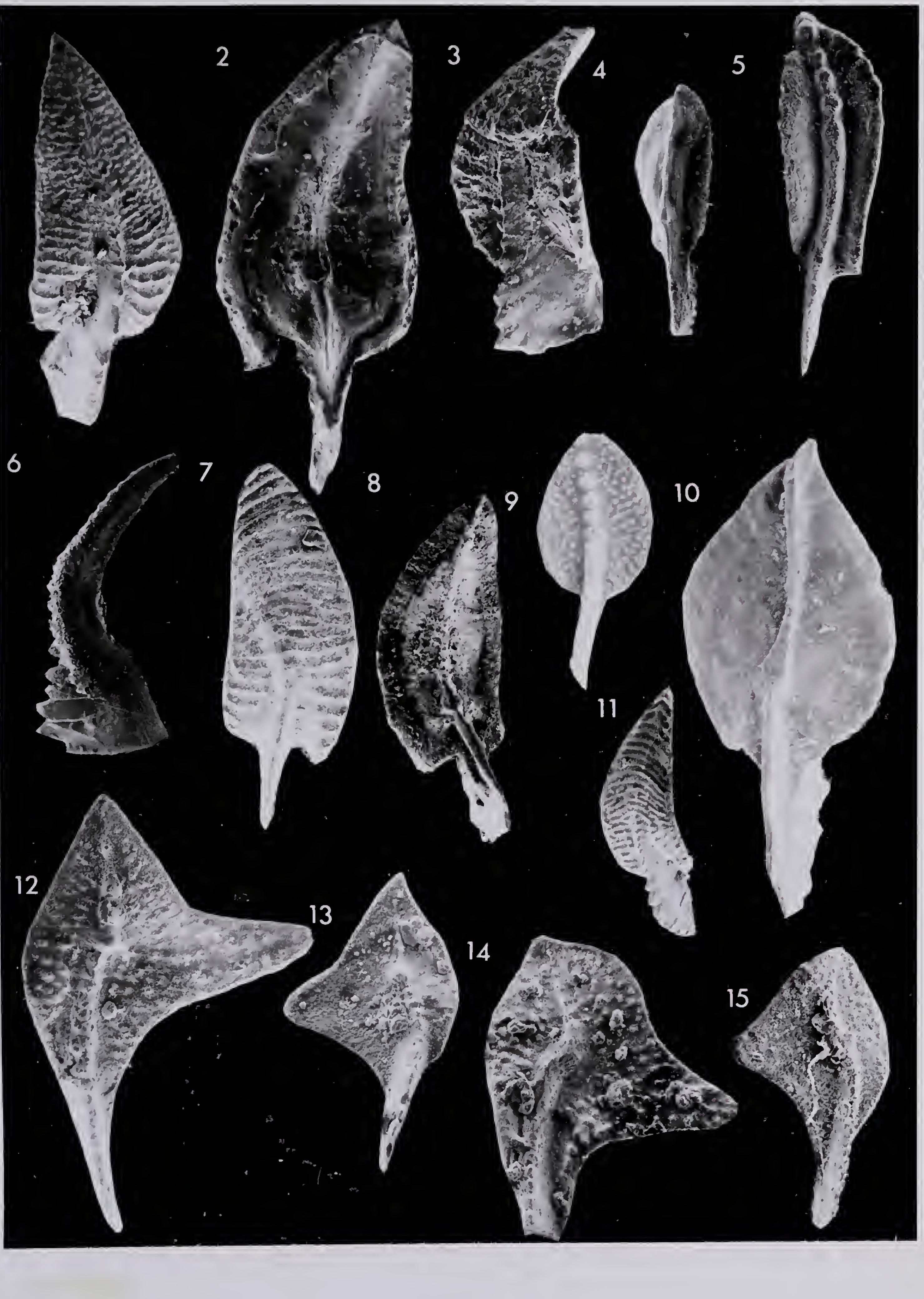
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PLATE 5

All magnifications X60 unless otherwise stated.

Figs. 1,2. *Polygnathus* new species D
(1) - 600X, close up of regeneration. (2) Oral view. Specimen from Twin Falls Formation sample (HR#1-1 1/2')

Figs. 3,4. *Polygnathus brevis* Miller and Youngquist (juvenile forms. (3,4) Oral views. Specimens from Tathlina Formation sample (HR#1-5').

Fig. 5. *Polygnathus* sp. 2.
(5) Oral view. Specimen from Trout River Formation sample (TR#4-40').

Fig. 6. *Polygnathus brevilaminus* Branson and Mehl
(6) Oral view. Specimen from Twin Falls Formation sample (LK2-20').

Figs. 7,8,9. *Polygnathus unicornis* Müller & Müller .
(7) Aboral view. (8) Side view. (9) Oral view. Specimens from Tathlina Formation sample (HR#1-5).

Fig. 10. *Trichonodella* Sa element.
(10) Specimen from Tathlina Formation sample (HR#1-8).

Fig. 11. *Trichonodella* Sa element.
(11) Specimen from Fort Simpson Formation sample (HR#3-10').

Figs. 12,13. *Apatognathus* sp.
(12,13) Specimens from Tathlina Formation sample (HR#1-1 mile upstream).

REPOSITORY

Figs. 2 - 13 U. of A. 3467 - 3478

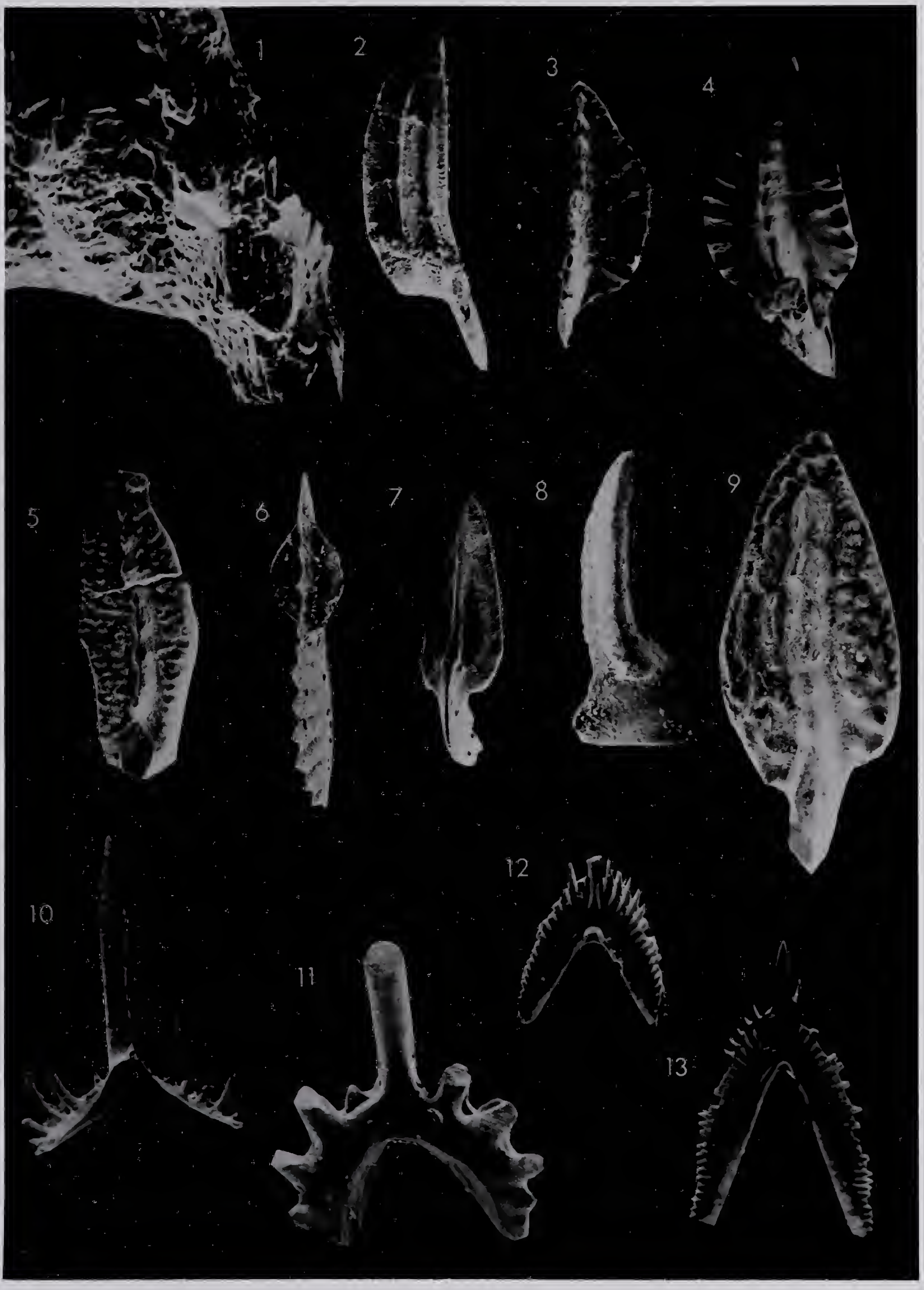
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PLATE 6

All magnifications X66 unless otherwise stated.

Figs. 1 - 4,6.	*Lonchodina* Pb element. (1) 25X. (2) Specimens from Tathlina Formation sample (HR#1-5'). (3,6) Specimens from Fort Simpson Formation sample (HR#3-9'). (4) Specimens from Tathlina Formation sample (HR#1-8').
Figs. 5,8,11,14.	*Ligonodina* Sc element. (8) 25X. (14) 30X. Specimens from Twin Falls Formation sample (HR#1-1 1/2').
Figs. 7,9.	*Ligonodina* Sc element. (7) 30X. (9) Specimens from Fort Simpson Formation sample (HR#3-9').
Figs. 12,13,17.	*Neoprioniodus* M element. (12) 30X. (13) 25X. (17) 120X. Specimens from Tathlina Formation sample (HR#1-1 mile).
Figs. 15,16.	*Hibbardella* Sa element. (15) 25X. (16) 30X. Specimens from Tathlina Formation sample (HR#1-5').
Fig. 10.	*Hindeodella* Sc element. (10) 30X. Specimen from Fort Simpson Formation sample (HR#3-10').

REPOSITORY

Figs. 1 - 17	U. of A. 3479 - 3495


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P L A T E 7

All magnifications X60 unless otherwise stated.

Figs. 1 - 3.	_Polygnathus_ new species E. (1,2) Oral views. (3) Aboral view. Specimens from Twin Falls Formation sample (HR#1-base).
Figs. 4,5,9,10.	_Polygnathus_ new species B. (4,5) Oral views. (9) Side view. (10) Aboral view. Specimens from Kakisa Formation sample (TR#2-20').
Figs. 6 - 8,12,13.	_Polygnathus_ new species F. (6,7,8,12) Oral views. (13) Aboral view. Specimens from Fort Simpson Formation sample (HR#3-9').
Figs. 11,14,15.	_Polygnathus_ new species H. (11) Aboral view. (14,15) Oral view. Specimens from Fort Simpson Formation sample (HR#3-9').

REPOSITORY

Figs. 1 - 15	U. of A. 3496 - 3510

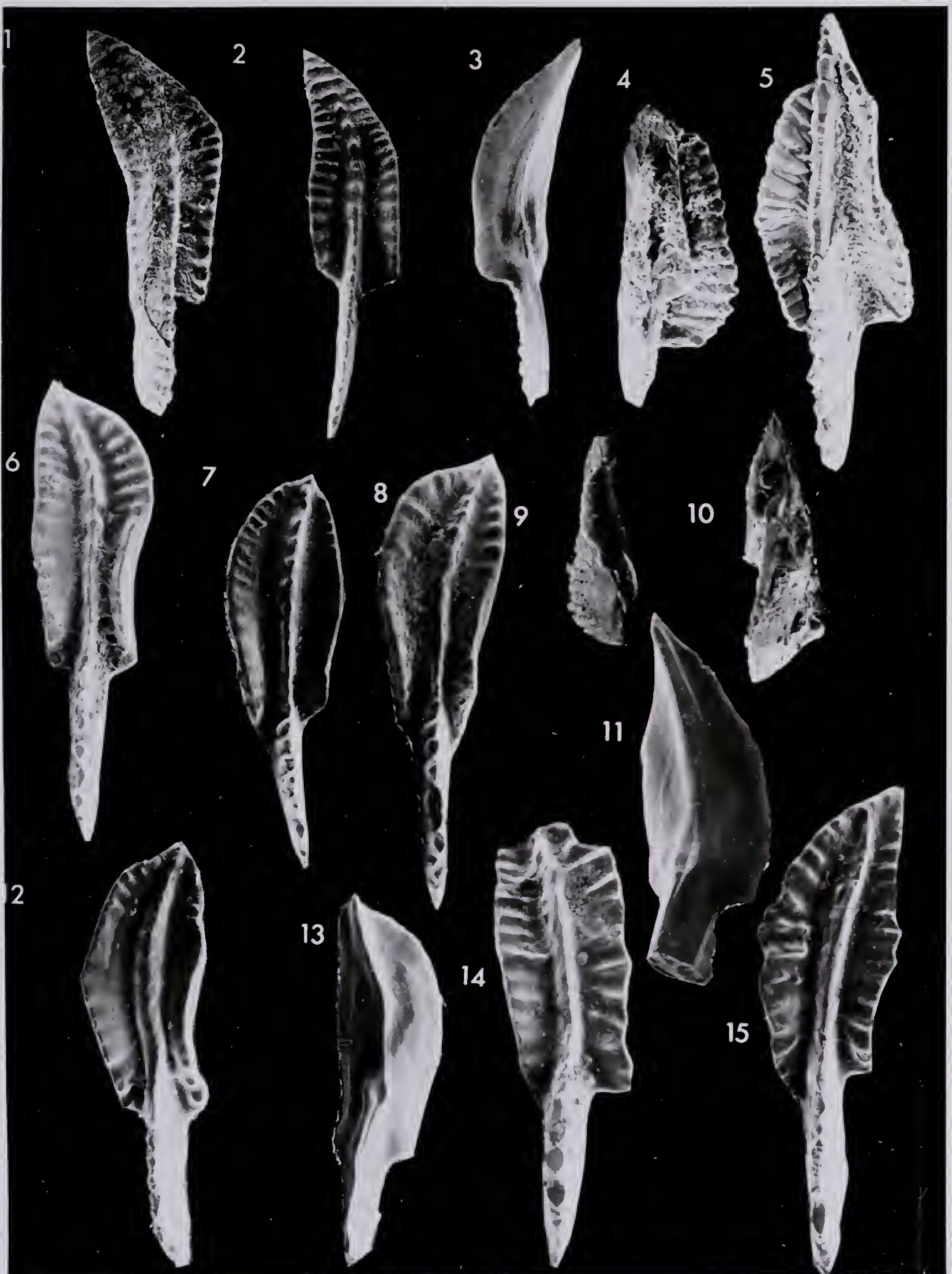
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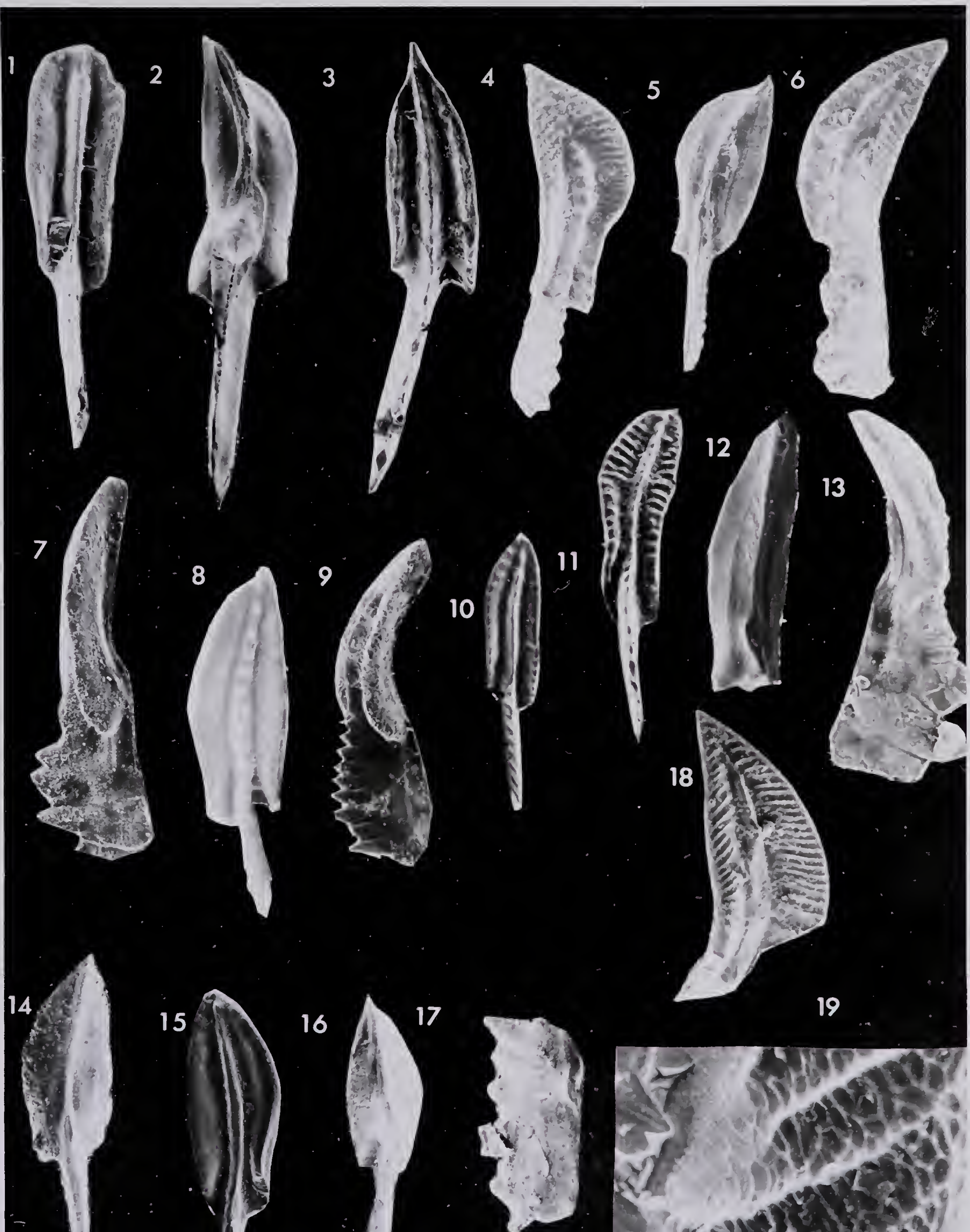
PLATE 8

All magnifications X60 unless otherwise stated.

Figs.	1 - 3.	Polygnathus xylus Stauffer . (1,3) Oral views. (2) Aboral view. Magnification 120X. Specimens from Fort Simpson Formation sample (HR#3-9').
Figs.	4-6,13,18,19.	Polygnathus new species C. (4,6,18) Oral views. (5) Aboral view. (13) Side view. (19) Magnification X600 of oral surface showing cellular ornament. Specimens from Kakisa Formation sample (TR#2-20).
Figs.	7-9,14-16.	Polygnathus new species D. (8,15) Oral views. (7,9) Side views. (14,16) Aboral views. Specimens from Twin Falls Formation sample (HR#1-1 1/2').
Fig.	17.	Spathognathodus cf. S brevis Bischoff & Ziegler . (17) Side view. (HR#6-10')
Figs.	10 - 12.	Polygnathus new species I (10,11) Oral views. (12) Aboral view. Specimens from Fort Simpson Formation sample (HR#3-9').

REPOSITORY

Figs.	1 - 17	U. of A. 3511 - 3526



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